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SURGERY OF LUMBAR INTERVERTEBRAL DISK PROTRUSION*

A STUDY OF PRINCIPLES AND RESULTS BASED UPON ONE HUNDRED CONSECUTIVE CASES SUBMITTED TO OPERATION

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INTRODUCTION

EVEN a cursory perusal of current medical literature will reveal a considerable diversity of opinion among surgeons who operate upon cases of prolapsed intervertebral disk,† as to the frequency with which these lesions produce symptoms and the principles governing their operative treatment. All who work in this field have had their successes and their failures. They have observed patients on whom immense benefit was conferred, as well as others on whom the degree of improvement failed to reach expectations. Furthermore, in some of the cases benefited, the findings at operation may have seemed inadequate to account for symptoms, whereas in still others a definite lesion was dealt with apparently adequately, but symptoms persisted or later recurred.

This paper is concerned primarily with a consideration of the various factors which, in our experience, make for success or failure in intervertebral disk surgery, particularly as applied to the lumbar region. It is based mainly upon an analysis of the clinical, operative, and follow-up findings in 100 consecutive cases submitted to operation with a diagnosis of prolapsed lumbar intervertebral disk, but a number of other cases have been included to illustrate and amplify certain points. Since operation all patients in our main series have been followed up for periods of from one to four years. In brief, this present investigation shows, first, that lumbar intervertebral disk lesions provide the underlying pathological basis of most cases of severe and persistent sciatica and of many cases of severe low-back pain, and, secondly, that the results of surgical treatment may be satisfactory, provided attention is paid to certain principles to be discussed.

CASE MATERIAL

Our main series of cases, which has been analysed in detail, comprises the first 100 patients with sciatica and low-back pain, occurring singly or together, submitted to operation in the recently established Neurosurgical Unit between September, 1943, and September, 1945. A consideration of our experiences with myelography in this series has already been published (Begg, Falconer, and McGeorge, 1946), while certain features of diagnosis and aetiology will form the subject of a third study. Patients in this series may be divided into two main groups :—

A.—A group of 77 cases where severe and intractable sciatica predominated.

B.—A group of 23 cases where severe and persistent low-back pain predominated.

These patients came to the Neurosurgical Unit from all parts of New Zealand, and include all grades of society. It is impossible to determine what proportion they represent of the total in-patient admissions of the various hospitals concerned. They were selected by us, however, from a larger group, estimated at from 300 to 350 patients, with leg or low-back pain, referred to individual members of the team for an opinion. Operation was not advised in most cases, either because the degree of disability was insufficient to warrant surgery, or because an adequate period of bed-rest had not previously been tried.

It is of interest that in this group a history of possible antecedent trauma was obtainable in only 44 of the 100 cases. When trauma initiated symptoms, it was usually followed immediately by the development of low-back pain, and, after a variable interval, of sciatic pain as well. Sometimes, however, leg pain appeared at once. Bending strains were the most common form of trauma. Quite often in cases where the patient's present symptoms appeared to have originated in trauma, careful questioning would elicit an earlier history of mild or forgotten episodes of low-back or even of leg pain. In most cases no history of causal strain was forthcoming, or else the degree of strain which the patient thought had provoked symptoms seemed too trivial. Thus in three instances pain had suddenly struck a patient sitting comfortably at

* Part of this paper was delivered by one of us (M. A. F.) as a Hunterian Lecture before the Royal College of Surgeons on Oct. 17, 1947.

† In this paper we regard the terms 'prolapse', 'protrusion', 'rupture', 'slipped disk', and 'herniation', as synonymous generic terms to cover all types of disk degenerations which may produce nerve-root irritation. The terms 'projection', 'extrusion', 'intermittent prolapse', and 'scarred disk' are employed to denote individual types of disk lesion, as will be defined in the text (*see also* Begg, Falconer, and McGeorge, 1946).

table lifting a spoonful of food or a cup to his mouth, while in several other instances symptoms came on suddenly for no apparent reason, and even in patients lying in bed. We do not feel, therefore, that trauma is the significant aetiological factor in disk protrusion which many people have considered it in the past.

As regards clinical features in this series, a constant sign was exacerbation of pain on coughing or sneezing. Some degree of limitation of straight-leg raising was present in nearly all cases of sciatica, in association with a slight degree of weakness of ankle movement. Rigidity of the lumbar spine was present in all cases of low-back pain, and in most cases of sciatica. Absence or diminution of the ankle-jerk was often present with protrusion at the lumbosacral space, while sensory disturbances conforming to either the fifth lumbar or first sacral dermatomal patterns were present in a large proportion of cases (Falconer, Glasgow, and Cole, 1947). The protein content of the cerebrospinal fluid was normal (below 50 mg. per 100 c.c.) in 74 cases, between 50 and 100 mg. in 23 cases, and over 100 mg. in 3 cases, the highest level observed being 180 mg. Further consideration of the clinical features and their significance will be deferred to a later communication.

A detailed discussion of the results of operation in our patients will follow in this paper. At this stage we may summarize our findings by stating that, in each case of sciatica, disk prolapses were found at operation affecting one or both of the lower two lumbar intervertebral disks, and were dealt with surgically. Eventually all cases of sciatica were improved on their pre-operative status, although for various reasons to be discussed 9 cases required more than one operation. Forty-one per cent of all cases were completely relieved of leg and low-back pain, and though the remainder had persistent symptoms, in most cases these symptoms were appreciably lessened. Of the cases with low-back pain occurring alone, all but one were shown at operation to have intervertebral disk lesions. Benefit was eventually conferred in all but 2, but in 5 cases in this group further operations were required before these results were achieved.

The lessons learnt from these cases may now be considered under three main headings: first, factors influencing the success or failure of operative treatment; secondly, problems of subsequent operations for continued or recurrent symptoms; and thirdly, recognition of other lesions which may simulate disk protrusion.

FACTORS INFLUENCING THE SUCCESS OR FAILURE OF OPERATIVE TREATMENT

1. Selection of Cases for Operation.—It would appear important to bear two considerations in mind: first, the greater the degree of incapacity before operation, the better are likely to be the post-operative results; and secondly, most cases of acute sciatica or lumbago recover without operation, either spontaneously or after rest. We therefore do not operate unless a patient is so incapacitated that he is unable to undertake light continuous work, and also has undergone a period of four or more weeks of complete rest without adequate relief. These rules are relaxed only in exceptional circumstances, such as the recent development of foot-drop.

If a patient with sciatica satisfies these considerations, and if also tuberculous, neoplastic, or other disease of the spine can be excluded, he is generally accepted for operation. A patient has seldom been excluded because his symptoms seemed largely psychological. Naturally it is desirable that patients should appear mentally stable and reliable, but in a number of instances early in this series, having first deferred operation because of uncertainty regarding the genuineness of the patient's disability, we eventually operated with surprisingly satisfactory results. We now consider that, if a man appears to have a genuine basis of disability, even though it is exaggerated by psychological features, and if his disability appears intractable, he should be offered the choice of operation. In several of our patients a diagnosis of 'anxiety neurosis' had previously been entertained, and it has been gratifying how often and how completely these patients were benefited by surgery.

Patients with intractable sciatica generally exhibit physical signs, which may be marked, but which quite often are slight (Falconer, 1944). Of these signs the most constant are aggravation of pain by coughing or sneezing, limitation of straight-leg raising, and rigidity of the lumbar spine. Many cases of sciatica present additional features, such as absence of an ankle-jerk, a sensory disturbance, a scoliosis or other deformity of the lumbar spine, or an increase of protein in the cerebrospinal fluid, but these features, although of significance from the view-point of localization of the disk lesion, do not influence the decision to operate. Likewise with myelography, which we carried out in most cases. We were often helped considerably in localizing the lesion and foretelling its nature by this procedure, but in the few instances where the myelogram was normal we were not deterred from proceeding to operation.

In selecting for operation cases of low-back pain without sciatica, more caution was observed. We accepted only those patients who, in addition to having severe and intractable pain which had not responded to a month's bed-rest, exhibited signs of rigidity and tenderness in the lumbar spine and positive myelographic evidence of a disk protrusion. At the time of our first operation in this group, only one report of a comparable case had come under our notice (Baker and Soniat, 1940). Our experience in this field has not yet been sufficient to warrant the relaxing of these criteria.

Age has not deterred us from operation if the foregoing criteria are fulfilled. Although most patients disabled by disk prolapse come within the third, fourth, and fifth decades of life, we have operated in this series on patients between the ages of 16 and 60 years.

2. Points in Operative Procedure.—It stands to reason that, if the best results are to follow operation, the pathological disk must be dealt with properly. There are certain principles of operative procedure which are not generally appreciated, and hence require emphasis.

a. Adequate Exposure of the Affected Disk.—In introducing the present era of intervertebral disk surgery, Mixter and Barr (1934) submitted their cases to laminectomy of several lumbar vertebræ, opened the lumbar theca, and so approached the lesions transdurally. As collective experience grew, surgeons recognized that a more limited laminectomy would suffice, and that most disk lesions were better dealt with by an extrathecal approach, after the lateral border of the theca and its appropriate nerve-root had been retracted medially. Then, in 1939, Semmes and Love independently described the interlaminar exposure which has since become widely adopted. In this procedure the disk lesion is exposed merely by retracting the lumbar muscles from one side of the spinous processes, and by then incising the ligamentum flavum over the affected interspace, after perhaps nibbling away a small portion of the bony lamina immediately above. Advocates of this interlaminar approach claim that, by disturbing the integrity of the spinal column as little as possible, the post-operative convalescence is shortened and the end-results are improved.

In our experience, however, the exposure provided by these peep-hole explorations has often proved inadequate both for inspecting the disk properly and for dealing with it thoroughly. This has been noticeable particularly in heavy, thick-set persons, in cases where the summit of the disk protrusion lies anterior to the theca, and where the disk lesion and the appropriate nerve-root are obscured by a thick venous plexus. Moreover, we have not noticed any increased disability in those patients from whom a vertebral spine and lamina have been removed. We have not hesitated, therefore, to perform a laminectomy whenever there was difficulty in securing a good exposure and have found that removal of the whole fifth and the lower half of the fourth lamina gives good access to the lower two intervertebral disks. In fact, laminectomy was performed in 61 of our 100 patients, and these have included some of our best results. For instance, one patient won a national wood-chopping and tree-felling contest some eighteen months after laminectomy for prolapsed intervertebral disk; while another, training as a commando, seven months after laminectomy had jumped frequently from heights of 12 to 15 ft., to land on his feet without discomfort. On the other hand, many of our disappointments followed unilateral interlaminar explorations, because the limited exposure of the disk had made adequate removal of its interior impossible.

Occasionally bleeding from an engorged venous plexus surrounding the theca and extrathecal nerve-roots has proved troublesome. To lessen this difficulty a sand-bag is placed under the groins and a pillow under the chest as the patient lies prone upon the operating table. This manœuvre, by avoiding pressure on the abdomen, reduces the venous congestion within the spinal canal. In spite of this precaution, however, venous bleeding may create a problem. It is our practice first to seal the major venous channels with a coagulation diathermy current briefly applied through the points of fine dissecting forceps, and then to divide the thrombosed segment with scissors. Any venous bleeding, not controlled by diathermy, can then be stopped by packing small pledgets of cotton-wool into the lateral extrathecal space above and below the pathological disk. It is thus possible to secure a dry exposure of a disk no matter how extensive is the surrounding venous bed. At the conclusion of operation if the bleeding recurs after the pledgets are removed, muscle 'stamps' may be applied in their place.

b. Recognition of the Pathological Disk at Operation.—In most cases the affected intervertebral disk presents a well-marked backward projection, which in cases with sciatica is so situated that it abuts upon a nerve-root. The summit of the disk protrusion may lie directly anterior to the nerve-root, or, if more medially placed, anterior to the theca. Sometimes a cartilaginous fragment is found extruding into the extrathecal space through a small hole in the annulus fibrosus. In both these circumstances the identity of the affected disk is at once evident, but in other cases it may not be easy to recognize the pathological disk.

This probably explains why many surgeons, when describing their experiences in this field of surgery, have reported a proportion of negative explorations which may be as high as one in three (Verbrugghen, 1943; Shinners and Hamby, 1944; Munro, 1945; Krayenbühl and Weber, 1945; Holmes and Sworn, 1946; etc.). Dandy drew attention to this when, in 1941, he introduced the concept of 'concealed ruptured disks', which he said occurred in 28 per cent of his case material. These disks, he pointed out, bulge only slightly, and are distinctly softer to the touch than a normal disk. When palpated with a probe they give a sense of fluctuation, and sometimes present a small orifice through which the point of a probe can be readily passed into the interior of the disk. When the covering annulus fibrosus is incised, necrotic disk material does not extrude spontaneously, while with almost no pressure the point of a curette or forceps will sink deeply into the intervertebral space. The contents of such a disk can readily be obtained by curettage, and Dandy described them as composed of soft, mushy, brownish material. We would draw issue with him on this point only, for usually we have obtained tough, white, fibrous, and shreddy material instead. We agree with him that the results of surgery in protrusions of this type are as satisfactory as with other types.

It is evident, then, that intervertebral disk lesions may present diverse macroscopical appearances. From our operative and myelographic experiences we consider that disk prolapses may be subdivided with advantage into four groups, as follows (*Fig.* 241):—

i. *Projections*: This type takes the form of a localized, smooth-domed, and glistening projection, formed by nucleus pulposus material which is still covered by intact but thinned annulus fibrosus. This is the commonest type of prolapse, and occurred in 66 patients in our series, forming 55 per cent of all protruded disks removed at operation.

ii. *Extrusions*: In this type fragments of nucleus pulposus of varying size are seen escaping into the extrathecal space. This type occurred in 16 of our patients, and formed 13 per cent of all protruded disks removed at operation.

iii. *Intermittent prolapses*: Most of the characteristics of this type of lesion have been described in the preceding paragraph, for they are those of Dandy's " concealed ruptured disk ". We, however,

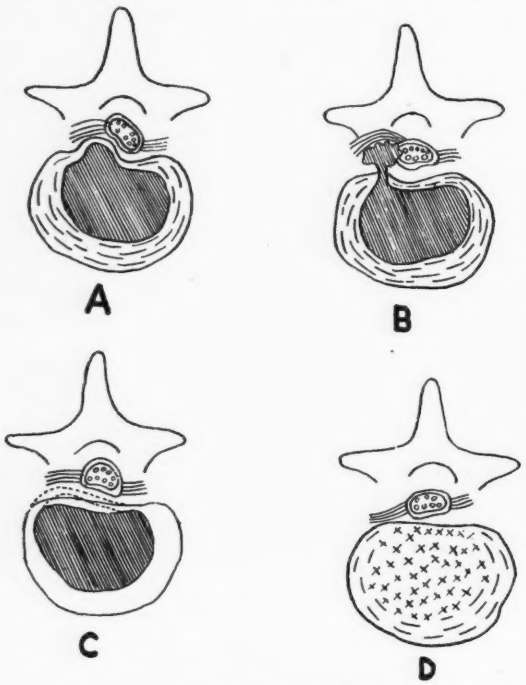


FIG. 241.—Diagrammatic representation of the four main types of disk prolapse. A, Projection; B, Extrusion; C, Intermittent prolapse; and D, Scarred disk.

prefer the term 'intermittent prolapse', for it indicates an important characteristic of the lesion, one which suggests how symptoms may be produced. This type of lesion protrudes only when the intervertebral disk is subjected to certain strains, and if

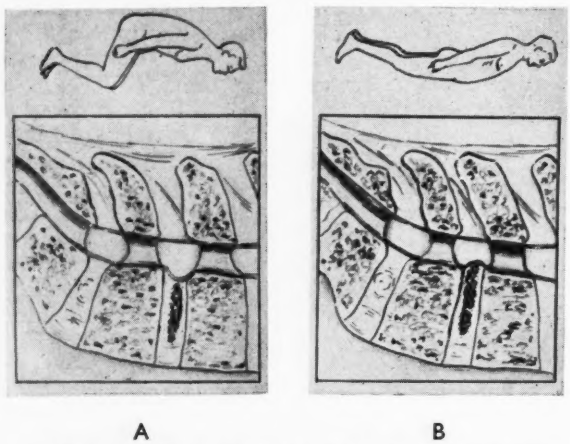


FIG. 242.—Diagrams illustrating the effect of 'hyperextension' manœuvre as performed at operation. A, There is no projection backwards of the weakened disk, which is relaxed; B, With hyperextension the disk protrudes backwards.

the patient is relaxed, as when he lies under anæsthesia prone upon the operating table with his hips flexed, it may not bulge at all. Such a disk can often be made to protrude at operation by breaking the table so as to hyperextend the patient's hips and spine (*Fig.* 242). A normal intervertebral disk is not appreciably affected by this 'hyperextension manœuvre', but a degenerate disk affected by an intermittent prolapse will usually bulge appreciably. These intermittent disk protrusions occurred in 33 of our patients, forming 27 per cent of all protruded disks removed at operation.

iv. *Scarred disks*: These represent a late stage of disk prolapse. Over a period of years the disk space becomes greatly diminished in width, and the opposing surfaces of the vertebral bodies become sclerotic and exhibit osteophytic outgrowths at their margins. Accompanying these changes the theca and extrathecal nerve-root may become firmly

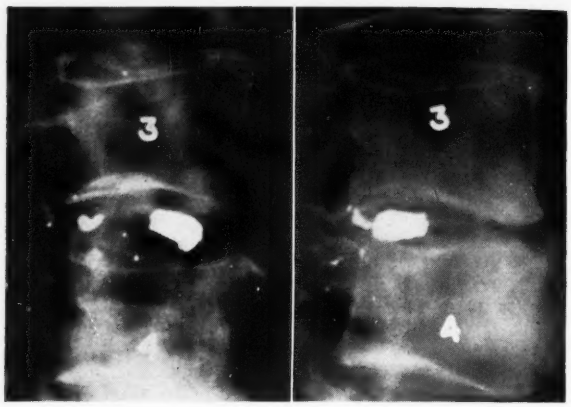


FIG. 243.—Lateral radiographs of patient shot in the midline of the back. A, A few days after wounding bullet is lodged in centre of third lumbar disk; B, One year later disk space is narrowed and bullet is displaced backwards as result of weight-bearing and other stresses.

adherent to the back of the intervertebral disk. The degenerated disk may still project backwards, although to a smaller extent than formerly. Most scarred disks of this type have probably ceased to cause disabling symptoms, except when several disk spaces are affected, leading to structural rigidity of the spinal column and to persistent and annoying backache. Now and then, however, a scarred disk by implicating a nerve-root may continue to cause persistent and disabling root-pain. Disk prolapses of this type were found in 6 patients of this series, and formed 5 per cent of all disk lesions dealt with at operation.

Of equal importance to the recognition of a pathological disk, once it is exposed, is the diagnosis beforehand of its level. We employed myelography as a routine pre-operative measure and found it valuable in foretelling not only which disk or disks were affected, but also the nature of each individual prolapse (Begg, Falconer, and McGeorge, 1946). Useful information can also be derived from a study of plain radiographs (Begg, 1947). In addition, in some of our later cases, we employed at operation the spinal mobility test, first described by Dandy (1943). This test is performed by seizing with forceps each exposed spine in turn, and attempting to rock it on its neighbours. Generally a definite increase of mobility is found between the two spines bordering on the pathological disk, but in a few instances no undue mobility can be discerned, while

in some scarred disks movement at the affected disk space may even be restricted. This test, therefore, is useful, though not infallible, in confirming at operation the level of the affected disk.

c. Necessity for Thorough Curettage of the Affected Disk.—This is the most important single precaution to be observed during an intervertebral disk operation.

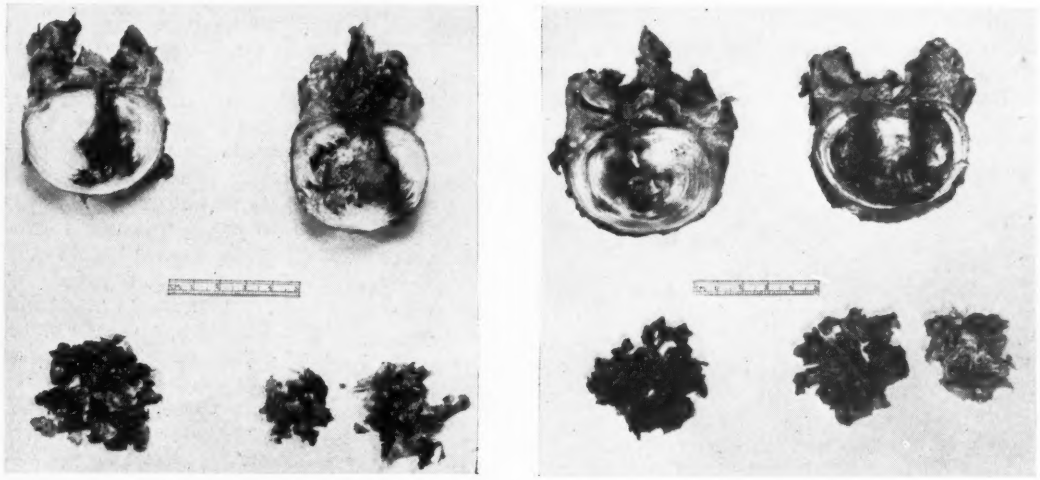


FIG. 244.—Photographs comparing the effect of unilateral curettage and of bilateral curettage of lumbar disks. The amounts of disk tissue removed are shown beneath. The removals were performed on cadavers and two examples are shown to illustrate the variations between cases. Note that the annulus fibrosus was pierced in the first case. In each bilateral curettage the removal was completed on one side before the second side was undertaken.

If any loose or readily detachable fragments of tissue are left behind within the interior of the disk, such fragments are likely to be forced through the operative opening in the annulus fibrosus, once weight-bearing or other comparable stresses are again taken by the spinal column (*Fig.* 243). These extruded fragments may then lead to either a continuance of the old symptoms or the development of new symptoms.

Usually the affected disk is filled with tough cartilaginous material, greyish though sometimes brownish in appearance, which on removal breaks up into irregular stringy fragments or plaques. This material results from desiccation and necrosis of the nucleus pulposus. Sometimes, however, the degenerate changes in the nucleus pulposus may not have progressed so far, and the interior of the disk may still contain a quantity of grey gelatinous tissue, which resembles more closely the nucleus pulposus of the adolescent. In either circumstance it is essential that at operation all loose or readily detachable tissue should be removed, as has recently been stressed particularly by Hyndman (1946). Sometimes it is possible to remove a sufficient amount from one side of the theca, as when the disk prolapse is projecting only on one side of the midline. But often the removal of the degenerate nucleus pulposus cannot be made completely effective, unless it is carried out from the other side of the theca as well, because from a unilateral approach it is difficult to remove those portions of the nucleus lying immediately anterior to the posterior longitudinal ligament and the annulus fibrosus on the other side (*Fig.* 244). The exposure gained by a laminectomy as opposed to a strictly interlaminar approach has often determined the success of an operation.

We learnt the importance of thoroughly curetting the interior of a prolapsed disk, only after we had had experience of re-operation in several cases with persistent or recurrent symptoms. These cases will be detailed in a later section. As our experience has grown we have become more and more radical in our handling of a prolapsed disk. After exposing the prolapsed disk by retracting the theca and appropriate nerve-root medially, we incise the annulus fibrosus and then remove the interior of the disk

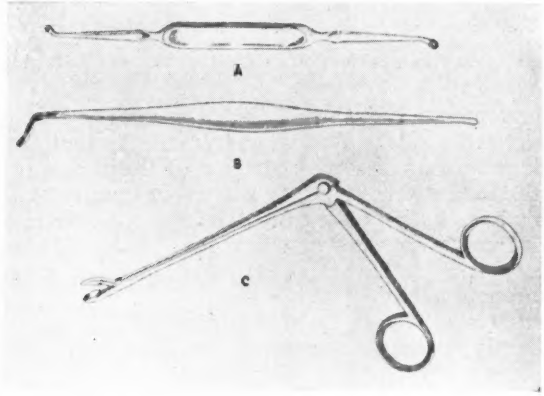


FIG. 245.—Drawing of instruments employed in curetting interior of an intervertebral disk. A, Angled mastoid curette; B, Clarke's curette for removing contralateral portion of disk; C, Pituitary rongeurs.

piecemeal by means of pituitary rongeurs and specially-angled scoops (*Fig.* 245). We continue curetting the nucleus pulposus until all readily detachable tissue has been removed, and only firm annulus fibrosus remains anteriorly and laterally. Particular care is taken to curette those recesses of the disk cavity which lie immediately anterior to the posterior longitudinal ligament or to the annulus

fibrosus just lateral to the operative opening, for it is surprising how frequently a large fragment can lie in either of these situations and not be disturbed by ordinary curetting movements (*Fig.* 244).

One of our chief concerns has been to decide, in individual cases, whether to explore the affected disk from both sides of the theca or be content with a unilateral exposure. *Figs.* 244, 246 show clearly how much of the interior of the disk is accessible from only one side of the theca. It is our practice to be content with a unilateral exposure when a disk protrusion presents with its summit situated entirely beneath a nerve-root lateral to the theca, and when all symptoms and signs have been confined to the leg on this side. But whenever the summit of a disk projection presents anterior to the theca, or is of the intermittent type, or whenever symptoms and signs have been present in both legs, we curette the disk from both sides of the theca. Echlin, Selverstone, and Scribner (1946) have made a similar recommendation.

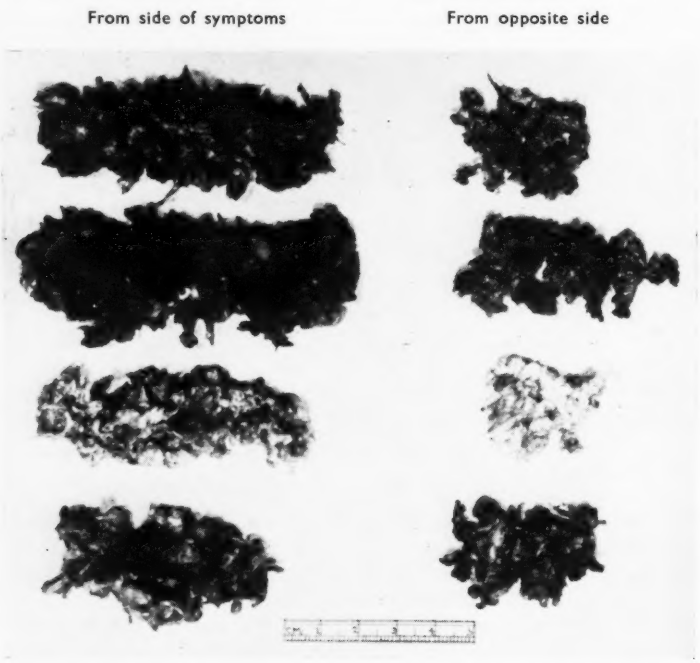


FIG. 246.—Amounts of disk tissue removed from each side of theca in four successive cases. In each instance the disk had been curetted as completely as possible from the side affected with symptoms before the other side was dealt with.

d. Other Points in Management of Operation.—Recently, several surgeons, in describing their operative experiences in chronic sciatica, have recorded that in from a fifth to a third of their cases they have been unable to find disk protrusions (Grant, 1944 and 1946); Krayenbühl and Weber, 1945; Munro, 1945; Holmes and Sworn, 1946; etc.). In many instances no abnormalities were observed, but in others such features as hypertrophy of the ligamentum flavum, extradural varices, and œdema and swelling of an intrathecal nerve-root, have been noted and mentioned as possible causes of symptoms. We, too, have observed these features, but in our experience they have always been associated with disk prolapses, usually of the intermittent type, which can be revealed at operation by the 'hyperextension manœuvre'. Thickening of the ligamentum flavum and marked prominence of the extrathecal veins we have regarded as normal anatomical variations, but pronounced swelling of a nerve-root we have considered as a secondary effect of nerve-root compression, and not as evidence of a primary neuritis which some have claimed for it (Holmes and Sworn, 1945; Munro, 1945; etc.). An analogous swelling of a nerve-trunk proximal to the site of a compressing lesion has been observed experimentally by Denny-Brown and Brenner (1944).

In 7 of our cases, with symptoms varying from six weeks' to many years' duration, an appreciable degree of matting of the roots of the cauda equina by leptomeningeal adhesions (meningitis serosa circumscripta) was noted within the theca, and in each instance it was associated with a disk prolapse. Six of these cases were relieved by removal of the prolapse. The condition may have been present in other cases, for the theca was opened in only a minority of patients, often only to ascertain the significance of strange myelographic appearances. Meningitis serosa circumscripta has been regarded as one of the causes of sciatica (Kulowski and Scott, 1934; Selinsky, 1936). The aetiology of this condition appears obscure (Elkington, 1936; Elsberg, 1941), but on a few occasions we have also noted it in association with disk protrusion in the thoracic and cervical regions of the spinal cord, as well as with chronic compression of the cord by malunited fractures of the spine. We therefore feel that the meningitis serosa circumscripta in such circumstances should be regarded rather as a secondary condition, and that disk prolapse is one of its causes.

A few surgeons recommend that, in addition to removal of the disk protrusion, the posterior root of the nerve which is being compressed should be divided. This Bradford and Spurling (1945) do within the extrathecal dural sleeve of the nerve-roots, while Petit-Dutaillis and de Sèze (1945) do so intrathecally. We, however, have seldom performed posterior rhizotomy nor seen the necessity for it. Our follow-up results show that removal of a prolapsed disk alone is necessary for the relief of sciatica. The addition to the operative procedure of what should be a needless step is in a sense a confession of failure on the part of the surgeon to deal adequately with the primary lesion.

Aitken and Bradford (1947) report that among surgeons in the United States there is an almost universal tendency to decompress the nerve-roots by enlarging the laminectomy laterally. In so doing the facets are often partially or completely destroyed. This they deprecate, unless the surgeon intends to perform a spinal fusion, for it can cause persistent back pain and instability after operation. In none of our cases did we decompress a spinal nerve in an intervertebral foramen.

Some surgeons have advocated spinal fusion in a proportion of cases (Barr and Mixter, 1941; Ghormley, Love, and Young, 1942; etc.) but the general consensus of opinion now seems to be that such a step is seldom, if ever, necessary (Dandy, 1943; Mixter, 1945; etc.). Spinal fusion was performed in a few cases in our series, but did not improve the end-results. It only added considerably to the duration of the convalescence.

3. Adequate Management of the Convalescence.—In some clinics it is customary to get patients up out of bed about the eighth or tenth day following operation, and to encourage them to return to work within a month. We feel that a slower and more graduated convalescence gives better results. Our experience with re-explorations shortly after the original operation has shown us that it takes several weeks before healing is consolidated in the various layers of the wound. One of us (M. A. F.) in a prior experience elsewhere recalls that an appreciable proportion of patients, who were allowed up within ten days, complained of tiredness and disabling pain in the back which might persist for several weeks, and which would often cause the patient to become dissatisfied with his progress. Some of these patients, when tired, would develop a troublesome kyphosis of the lumbar spine.

In such cases insufficient attention was paid to the wasting and weakness which commonly appear in the erector spinæ muscles following disk operations, and which must be corrected before rehabilitation is complete (Falconer, 1947). An analogous condition is seen in the wasting and weakness which develop in the quadriceps femoris muscle after operations on the knee-joint. It is now our practice to keep patients in bed three weeks, and on the tenth day, when the stitches are removed, to commence exercises in bed designed to strengthen the erector spinæ muscles.* In these exercises the patient lies prone, and raises and lowers his head and shoulders up to a dozen times, alternating with lifting his legs off the bed. In advanced exercises he lifts both shoulders and legs together. These exercises are repeated many times daily, and by the time the patient is ready to leave his bed his back muscles have usually regained most of their former strength. He then remains up for a rapidly increasing period each successive day, and is given training in walking and body-carriage, until by the end of a week, i.e., about four weeks from operation, he has been up all day. In refractory cases an even longer period may be required at this stage of convalescence. The patient is then allowed home, and he is instructed to increase his physical activities slowly and steadily to a point short of fatigue, by such means as walking, cycling, swimming, and light gardening. Heavy lifting and bending are avoided during this period. We usually find that it takes from two to four months for a man to resume light work, and from four to six months to resume heavy work.

* Since this paper was submitted for publication, one of us (M. A. F.) has visited the Montreal Neurological Institute (Drs. W. V. Cone and R. Rabinovitch). Most of the conclusions reached in this paper are in agreement with practice there, except in respect of the duration of bed-rest after operation. At Montreal a radical removal of the affected disk is undertaken, but patients are got out of bed towards the end of the first week after operation. Erector spinæ exercises, however, are continued into the convalescence. It may well be that we have kept our patients in bed longer than is really necessary, for this point of management was introduced by us at an early stage of our experience when we were dealing with disk prolapses only through a unilateral approach, and hence not always adequately.

PROBLEMS OF SUBSEQUENT OPERATIONS OR RECURRENT SYMPTOMS

Few surgeons have recorded their experiences of second operations in those cases in which symptoms have either persisted or else recurred after operation. Yet all who have published their results of operative treatment in large groups of patients have acknowledged an appreciable proportion of failures (Verbrugghen, 1943; Botterell, Keith, and Stewart, 1944; Grant, 1944 and 1946; Munro, 1945; Shinners and Hamby, 1944; Poppen, 1945; Krayenbühl and Weber, 1945; etc.). Of our 100 consecutive patients no less than 14 required a second or even a third operation because of persistent or recurrent symptoms. These latter cases form a most important group, because from them we learnt many important lessons of operative procedure and technique. They may be divided into four subgroups as follows:—

a. Cases in which the disk lesion responsible for symptoms had not been recognized at the original operation—3 examples.

b. Cases in which the responsible disk lesion had been dealt with inadequately at the original operation—8 examples.

c. Cases in which subsequent symptoms were due to a second disk protrusion occurring at another level—2 examples.

d. Cases in which spondylolisthesis developed producing symptoms—1 example.

Before describing each of these subgroups in turn, certain points of operative technique common to all secondary explorations may conveniently be discussed. Where the ligamentum flavum or any portion of the lamina has been removed, the dead space is firmly filled in by scar tissue which is strongly adherent to the theca. This scar tissue renders the second approach difficult. Furthermore, the nerve-roots and theca are invariably bound down by more scar tissue to the posterior aspect of the disk where it was previously explored. In order to prevent the theca from being opened inadvertently, it is our practice to expose the lateral bony wall of the spinal canal, and by dissecting the scarred theca from it to approach the posterior aspects of the vertebral bodies and so the intervertebral disks. The appropriate extrathecal nerve-root is usually located during this last stage of the exposure, but the dissection required to free it and to expose the back of the intervertebral disk may be tedious.

A. **Cases in which the Lesion responsible for Symptoms had not been recognized at the Original Operation.**—There are three such cases. In each it would seem that multiple disk protrusions

were present, but that at the first operation only one had been dealt with, leaving undisturbed the protrusion actually causing symptoms. Each patient was benefited subsequently by a second operation, although all three retained definite, though not disabling, symptoms of low-back pain. The following is an example :—

Case 6.—A 43-year-old woman, after having suffered low-back pain for twelve months and severe left-sided sciatica for ten weeks, underwent a spinal operation elsewhere. As her ankle-jerks were brisk and equal, the surgeon thought this indicated a compression of the fifth lumbar nerve-root, and consequently he explored only the fourth lumbar disk, which he found to be degenerate and so curetted. Symptoms were not relieved. Five months later myelography revealed an indentation of the thecal column opposite the fifth lumbar disk. Exploration at the Neurosurgical Unit then disclosed a typical disk projection at this level compressing the first sacral nerve-root. This was curetted through a unilateral interlaminar approach. Subsequently the patient was completely free of symptoms for ten months. She then developed slight recurrent symptoms of low-back pain and occasionally of sciatica, but was able to carry on with her duties.

Since our main series of cases was collected we have had three further patients, all of whom had been explored elsewhere for a suspected intervertebral disk lesion, but with negative findings, because in none of them had the correct disk space been explored. The following example illustrates the vicissitudes of diagnosis and treatment through which patients may pass :—

Case D. R—d.—A 30-year-old labourer had experienced thirteen years previously several attacks of severe low-back pain, each induced by some exertion. Then, starting seven years ago, he had been disabled for nearly four years by severe right-sided sciatica characterized by a lumbar scoliosis and an absent ankle-jerk. During that period he had undergone a gamut of treatments, including various forms of physiotherapy, several periods of a month's or more bed-rest in hospital, three manipulations of the spine and hip-joints under general anæsthesia, and several injections of saline or local anæsthetic solution in large quantities into the sacral epidural space or along the course of the sciatic nerve. Myelography was tried but was technically unsatisfactory. After two years of such treatments he underwent a lumbar laminectomy for suspected intervertebral disk lesion, but no lesion was found. Three months later a right-sided sacro-iliac arthrodesis was performed, also without relief. Throughout his long period of illness it was noted that sometimes his symptoms would disappear after a manipulation or injection, only to return again a few days or weeks later. At other times, however, similar procedures even when repeated by the same doctor would aggravate symptoms instead. Eventually after four years his symptoms disappeared, apparently spontaneously, and the patient then remained symptom-free until six weeks before his admission to the Neurosurgical Unit, when, while attempting to lift a heavy bale of wool, he developed a crippling attack of sciatica down the left or opposite leg.

Examination at the Neurosurgical Unit disclosed a rigid lumbar spine, slight weakness of dorsiflexion of the left ankle-joint, and absence of the left ankle-jerk. Radiographs revealed that the surgeon who had performed the original laminectomy had removed the second, third, and fourth lumbar laminæ, but had left the fifth lumbar lamina intact. The old spinal incision was therefore reopened, and this time the fifth lumbar lamina was removed. This disclosed a backward projection of the fifth lumbar disk approximately 8 mm. high, indenting the first sacral nerve-root on the left side. On the right side the first sacral nerve-root was firmly bound down to the disk by scar tissue, indicating a long-standing pathological process which has probably accounted for the earlier history of right-sided sciatica.

Following this last operation the patient made an uninterrupted recovery, and was freed of his pain. When interviewed six months later he had no pain apart from an occasional ache in the left calf. In spite of a medical injunction against heavy work, he reported that he was now engaged in pressing and baling flax, work which entailed his moving unaided with a wheelbarrow loads of up to 5 cwt.

These six cases illustrate two important points of operative procedure. The first is the importance of realizing that disk protrusions may be multiple. Sciatica can be caused by disk lesions at either of the lower two lumbar spaces, and therefore in operating on a case of sciatica it is necessary to ensure that after a prolapse has been dealt with at one of these spaces, a second disk prolapse does not remain at the other. Unless myelography has been performed beforehand and has exonerated the second disk space, the second space should also be explored at operation (Begg, Falconer, and McGeorge, 1946).

The second point is the difficulty which may be encountered in identifying the various vertebræ at operation. It is our practice to expose the back of the sacrum in every case, and to display the lowest ligamentum flavum which marks the lumbosacral junction. This junction can also be identified by seizing the various spines with forceps and rocking them to determine which is the lowest spine that can be moved on the sacrum. Having identified the lumbosacral junction, the various spines can be enumerated. Failure to ascertain the correct spinal levels probably explained why the fifth lumbar lamina was not removed in the case just cited, and hence why the protrusion causing symptoms was not disclosed.

B. **Cases in which the Responsible Disk Lesion had been dealt with inadequately at the Original Operation.**—There were eight such cases. In four, symptoms returned before the patient had even left hospital, and in the remainder, after a period of from two to twelve months. In some the symptoms recurred in the same leg, but in others they appeared in the opposite leg. In all eight cases it would seem that the fundamental fault was a failure to remove adequately at the original operation all degenerate and detachable tissue from the interior of the disk. Certain of these cases will now be described to illustrate important aspects of this problem.

Case illustrating appearance of sciatica in the opposite leg during the immediate post-operative period.—

Case 48.—A 43-year-old saleswoman had experienced three years before admission a sudden attack of severe low-back pain while she was bending down over her oven. Within three months she had developed a typical right-sided sciatica, which persisted for some weeks before disappearing completely. Then, nine months before admission to the Neurosurgical Unit, while again stooping, she suddenly developed a severe pain down the back of the opposite leg from hip to calf. This left-sided sciatica proved refractory to various forms of treatment, both medical and chiropractic, and during

the last two months became so severe that she could not move from her bed. At times pain would also appear down the back of her right leg and for some days she would have bilateral sciatica, always worse, however, in the left leg.

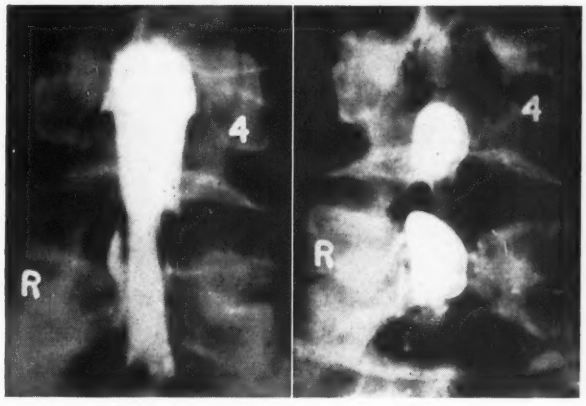
Examination on admission disclosed a marked scoliosis of the lumbar spine with a convexity to the left side, slight weakness of all movements of the left leg, but no diminution of the ankle-jerks, no limitation of straight leg-raising, and a normal cerebrospinal fluid. Lipiodol myelography revealed a filling defect of the thecal column on the left side opposite the fourth lumbar disk. A left-sided interlaminar exploration disclosed a disk projection approximately 6 mm. high, pressing against both the theca and the fifth lumbar nerve-root. A moderate amount of loose nuclear tissue was obtained when the disk was then curetted from this side (*Fig.* 247). The fifth lumbar disk was also inspected but appeared normal.

A B

FIG. 247.—Disk tissue removed from fourth lumbar disk in *Case* 48. A, From the left side at the first operation; B, From the right side at the second operation.

Following operation the patient was relieved of pain in her left leg, but complained instead of severe, persistent pain in her opposite leg. Consequently fifteen days later her wound was reopened and the fifth lumbar lamina removed. When the fourth lumbar disk was uncovered from the right side of the theca, it could be seen that there was still a backward projection of the disk approximately 4 mm. high, the summit of which was situated anterior to the theca and extended laterally to compress the right fifth lumbar nerve-root. A further quantity of degenerative nuclear material, comparable in amount to that obtained from the opposite side at the original operation, was then removed by curettage from the right side (*Fig.* 247). Following this second operation the patient was freed of her sciatica and low-back pain, and when last seen two and a half years later was back at her old occupation, experiencing only occasional aches in her left leg.

Case illustrating recurrence of low-back pain during the immediate post-operative period.— *Case* 56.—A 22-year-old student had developed low-back pain during the football season five months earlier. Six weeks before admission, without apparent additional injury, this low-back pain became severe and disabling. He underwent five weeks' continuous bed-rest, but was no better. Examination then disclosed a rigid lumbar spine and moderate limitation of straight-leg raising on either side. There was no weakness, sensory loss, or disturbance of tendon-jerks in either lower limb. The cerebrospinal fluid was normal. Radiography of the spine disclosed narrowing of both the fourth and the fifth lumbar disk spaces, while myelography revealed a filling defect of the thecal column opposite the fourth lumbar disk, particularly on the left side (*Fig.* 248 A). At operation the lower two lumbar intervertebral disks were explored from the left side only, and disk lesions were found and dealt with at both these levels. The lesion at the fourth space took the form of a small extrusion of nuclear material situated anterior to the theca; at the fifth space it was a prolapse of the intermittent type. Moderate amounts of degenerate tissue were obtained by curettage from both disks (*Fig.* 249).



A B

FIG. 248.—Myelograms of *Case* 56. A, Before first operation, showing lateral indentation of thecal column opposite fourth lumbar disk on the left side; B, Before second operation, showing an even more pronounced defect at the same level.

For the first twenty-one days after operation this patient was free of pain. Then, while the straight-leg raising test was being performed, he suffered a sudden and intense recurrence of low-back pain. As this pain persisted, myelography was repeated, disclosing this time a complete transverse filling defect opposite the fourth lumbar disk (*Fig.* 248 B). At a re-exploration on the thirty-first post-operative day the lamina of the fifth and the lower half of that of the fourth lumbar vertebra were removed. When exposed from the right side, both the fourth and the fifth disks were found to be still ridged

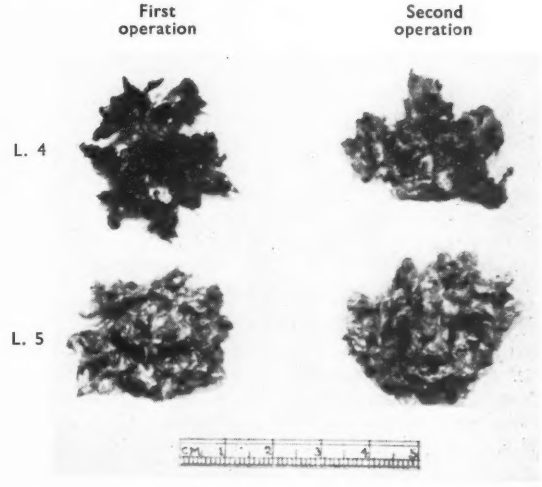


FIG. 249.—Disk tissue removed from fourth and fifth lumbar disks in *Case* 56. At first operation disks were explored from the *left* side only; at the second operation they were explored from the *right* side.

posteriorly as they lay anterior to the theca. They were therefore curetted from this side and amounts of degenerate disk tissue, comparable to those already removed from the opposite side at the previous operation, were readily obtained (*Fig.* 249). A point of interest was that at both disk spaces the related extrathecal nerve-roots

emerged from the theca just below the level of the disk, and consequently could not be compressed by the disk protrusion. This anatomical fact probably accounted for the absence of sciatica in this patient's history.

Following the second operation the patient was completely freed of low-back pain and has remained so for two and a half years.

These two patients were in hospital at the same time, and were the first in our series to undergo a second exploration. In both instances we were

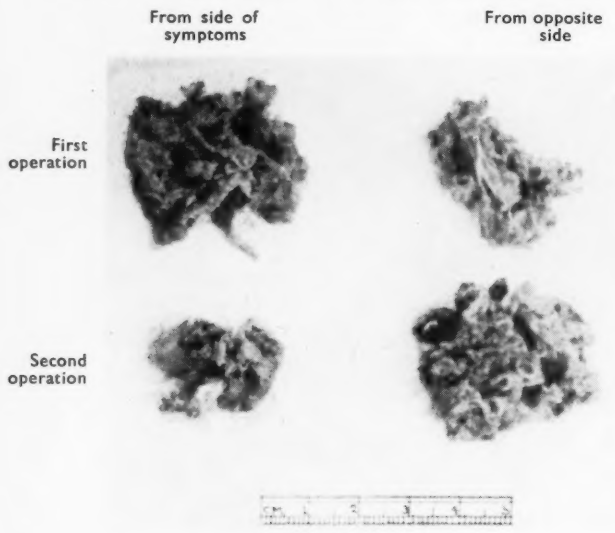


FIG. 250.—Disk tissue removed from fifth lumbar disk in *Case* 74.

dealing with midline disk prolapses, but the significance of this was not appreciated at this stage. We were then passing through a phase when most cases were being explored through a unilateral interlaminar approach. In the first case we operated on the side of continuous symptoms, in the second on the side on which the thecal indentation as revealed by myelography was greater. These two cases, however, made us realize that in patients in whom the disk prolapse was situated at or close to the midline, symptoms might persist or recur in the back or opposite leg, if only a unilateral curettage of the degenerated disk was performed.

In both cases at the second operation the interior of the disk was explored again from the side of the first operation, but without significant amounts of tissue being obtained. Later we were to learn from the following and other cases the importance of ensuring that all degenerate and detachable tissue is removed from within the interior of the disk.

Case illustrating recurrence of symptoms during the immediate post-operative period following bilateral curettage of the affected disk.—

Case 74.—A stout 46-year-old woman had for nine years complained of intermittent attacks of low-back pain, usually occasioned by minor strains. Six years ago she had experienced a severe attack of low-back pain as a result of falling off a bicycle, and this had continued for six months before easing off. It, however, did not disappear completely. Five months before admission she suddenly developed an exacerbation of low-back pain without obvious reason, and later the same day while walking felt the pain shoot down the back of the right leg. Next morning her right leg was weak and she limped. Her right-sided sciatica proved persistent and disabling. She spent many weeks in bed without relief, and also had various forms of physiotherapy and chiropractic treatment.

On admission she walked with a marked limp, and some forward flexion of her lumbar spine. The muscles of her right buttock, thigh, and calf were slightly wasted, and there was marked weakness of dorsiflexion of the right ankle. There was also numbness in the fifth lumbar dermatome. Radiographs disclosed marked narrowing of both the fourth and fifth lumbar disk spaces, while myelography suggested an extrusion of the fifth lumbar disk upwards alongside the theca on the right side to compress the fifth lumbar nerve-root (*see* Begg et al. 1946, Fig. 212). A fifth lumbar laminectomy was performed. Some fragments of nuclear material were found extruded as suggested by the myelogram, but there was still a large quantity of degenerate tissue remaining within the interior of the fifth disk, which was consequently explored and curetted bilaterally (*Fig.* 250).

Following operation her condition at first was most promising. Then, on the tenth night, she had a fit of coughing, and during it developed severe pain in her lower back extending down her left or previously good leg. This pain persisted. Myelograms, when repeated, seemed normal, but at re-exploration on the eighteenth post-operative day, a cartilaginous fragment, measuring 0·6 cm. long by 0·4 cm. diameter, was found wedged beneath the first sacral nerve-root on the left side. This had evidently extruded through the opening in the annulus fibrosus made at the original laminectomy. The interior of the disk was therefore curetted again, and to our amazement an appreciable quantity of degenerate disk tissue was again obtained (*Fig.* 250).

Following this second operation the patient was relieved of the pain in her leg, although she complained of a stiff and aching spine for some weeks, but when interviewed some eighteen months later she was completely free of symptoms, even of the low-back pain which she had had continuously for six years.

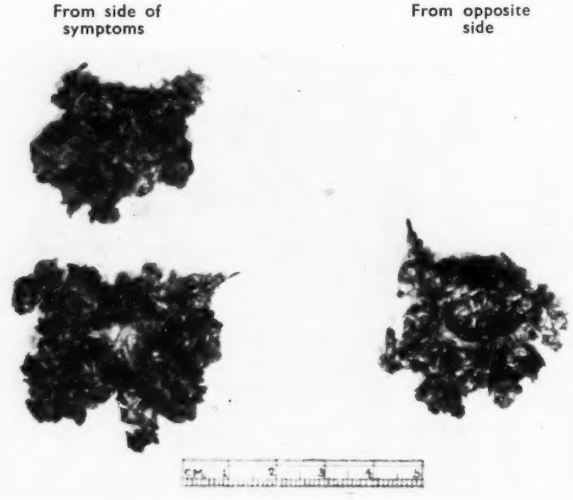


FIG. 251.—Disk tissue removed from fifth lumbar disk in *Case* 57.

Case illustrating recurrence of symptoms after a year.—

Case 57.—A 37-year-old returned soldier had two years earlier fallen from a stationary truck, and had

immediately felt a sharp stab of pain in the lower back. He then marched a few miles and developed left-sided sciatica which persisted, and proved refractory to various forms of treatment, including four month's bed-rest occasioned by an attack of typhoid fever. On admission to the Neurosurgical Unit he showed a flat lumbar spine with a slight scoliosis convex to the painful side, weakness of movement of the left ankle, and moderate limitation of straight-leg raising. The ankle-jerks were normal. A fifth lumbar laminectomy was performed, and a disk prolapse of the intermittent type found at the fourth space beneath the fifth lumbar nerve-root. This disk was curetted from the left side of the theca, and a moderate amount of degenerate disk tissue obtained (*Fig.* 251).

Following operation he experienced some transient weakness of the left ankle, but was free of pain. After six months he engaged in moderately heavy farm work, and was almost symptom-free for a year. Then one day while bending down to lift a log weighing more than 1 cwt. he felt something give in his back, and immediately developed a recurrence of left-sided sciatica. After nine months of severe symptoms the old laminectomy wound was reopened, after myelography had disclosed a filling defect at the old level (*Fig.* 252). An irregular fragment of cartilaginous tissue, measuring 2·2 by 0·7 by 0·7 cm., was found wedged under the fifth lumbar nerve-root, having extruded from the interior of the disk through the operative opening in the annulus fibrosus. The interior of the disk was therefore curetted for the

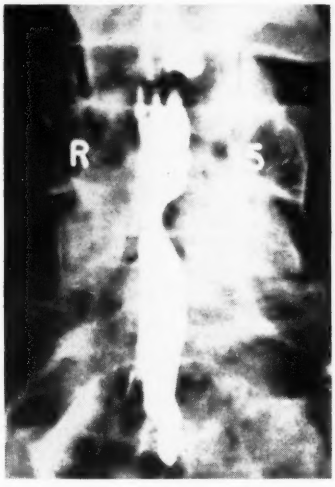


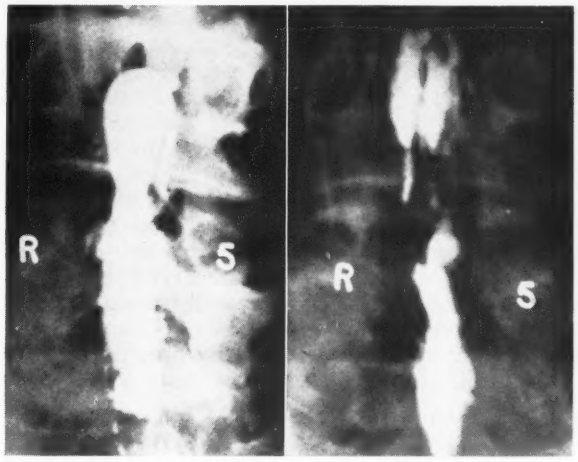
FIG. 252.—Myelogram of *Case* 57 before second operation, shows indentation of thecal column opposite fifth lumbar disk on left side, the site of the previous exploration.

second time, when an astonishing amount of degenerate tissue was obtained (*Fig.* 251). Following this second operation the patient has again been free of pain.

The fundamental fault in both these cases was that the diseased disk had been inadequately curetted at the first operation, with the result that some detachable tissue had been left behind within the interior of the disk. Subsequently during a period of strain—in *Case* 74 a bout of coughing some ten days after operation, in *Case* 57 an episode of heavy lifting a year later—fragments of this degenerate tissue had extruded through the operative site in the annulus fibrosus to compress a nerve-root and arouse recurrent symptoms. In both instances these recurrent symptoms were relieved by a second operation.

C. **Cases in which Subsequent Symptoms were due to a Second Disk Protrusion occurring at Another Level.**—There were two cases of this type. Both gave comparable histories, and therefore only one need be described.

Case 60.—A 38-year-old school teacher had suffered from intermittent attacks of low-back pain for many years. Three months before admission he assisted in the construction of a dwelling, and while hoisting a wall into position he suddenly developed an attack of pain



A B

FIG. 253.—Myelogram of *Case* 60. A, Before first operation, showing slight hour-glass constriction of thecal column opposite fourth lumbar disk; B, Before second operation, showing appearances of localized arachnoiditis opposite fourth lumbar disk, and in addition a slight hour-glass constriction opposite fifth lumbar disk not seen previously.

down the back of the right leg. This pain proved persistent and disabling, not responding to five weeks' bed-rest. On admission to the Neurosurgical Unit he showed marked lumbar rigidity, some wasting of the right buttock and calf, slight weakness of ankle movements, and absence of the right ankle-jerk. Radiographs showed narrowing of the fourth lumbar disk space. The cerebrospinal fluid contained 85 mg. of protein per 100 c.c., while myelography indicated a midline protrusion at the fourth lumbar disk (*Fig.* 253 A). A fifth lumbar laminectomy was performed and a disk protrusion of the intermittent type was found at the fourth space and dealt with by bilateral curettage. The fifth lumbar disk was also inspected, but seemed normal.

For eighteen months the patient was free of pain. Then, while lifting some heavy tables, he again developed severe back pain. Fifteen days later he woke up with a fresh attack of right-sided sciatica, associated once more with marked limitation of straight-leg raising. Six months later myelography was repeated, but proved difficult to interpret as there were features characteristic of leptomeningeal adhesions. There was, however, now a suggestion of slight constriction of the thecal column opposite the fifth space, indicating a midline prolapse (*Fig.* 253 B). The old spinal wound was re-opened. The fourth lumbar disk was re-explored but seemed firm. When the fifth lumbar disk, however, was exposed, a definite backward projection 4 mm. high, was found anterior to the theca, and was curetted from both sides. The patient's convalescence was straightforward, and he was again relieved of pain. Four months later he was back at work.

Considering the fact that in disk prolapse we are dealing with a pathological process which is likely to affect more than one intervertebral disk in

the lumbar spine, we might perhaps have anticipated that more than two patients would have returned with symptoms from a fresh disk prolapse. Certainly both lower lumbar disks were found to be prolapsed at the time of operation in one in every five of our patients. The lesson to be learnt is that the surgeon should always ensure that, after he has dealt with a prolapse at one of the lower two lumbar intervertebral disks, the other disk is not similarly affected. He may elect to do this by exploring both disks at operation as we did in many of our cases. We feel justified, however, in using myelography as a pre-operative measure to ascertain whether one or both of the lower lumbar intervertebral disks is at fault, and in this way we can often limit our operative intervention to the level of the diseased disk. In cases of doubt, however, we explore both disks.

D. **Case in which Spondylolisthesis supervened producing Symptoms.**—In one case an unusual complication supervened producing recurrent symptoms, which, until the new cause was disclosed at operation, were regarded as due to recurrence of a disk protrusion inadequately dealt with at the original operation. This case has a long and involved history which illustrates more than one complication of disk surgery.

Case 96.—A 35-year-old serviceman seven years previously had sustained a severe fall, developing immediately a sharp pain down the back of the right leg which was aggravated every time he coughed or strained. He was immobilized on a Bradford frame for ten weeks, after which a sacro-iliac arthrodesis was performed on the right side. Three months later he was discharged from hospital symptom-free, and he remained so for four years until he had a short return of sciatic pain occasioned by a fall. Then, a year before admission to the Neurosurgical Unit, he had a further fall, after which he experienced continuous, severe, and disabling right-sided sciatica. He received several forms of treatment, including immobilization in a plaster jacket for four months, followed by psychotherapy for a similar period, all without benefit.

Examination on admission disclosed a thin, introspective man exhibiting marked limitation of forward flexion of the lumbar spine, slight weakness of dorsiflexion of the right ankle-joint, diminished right ankle-jerk, and moderate limitation of straight-leg raising on that side. The lumbar cerebrospinal fluid was normal, as also seemed to be radiographs of the spine and myelograms, but, as the history and physical signs suggested a disk prolapse, operation was decided on. A right-sided hemilaminectomy of the fifth lumbar vertebra was then performed. The fifth lumbar disk seemed soft and semifluctuant, and moreover, ridged up when the spine was hyperextended on the operating table. It was therefore judged to be a prolapse of the intermittent type, and consequently was curetted, but only from the right side of the theca. Following this operation the patient had no more pain in the right leg, and for four months seemed relieved of all symptoms.

He then began complaining of pain in the coccygeal region and down the back of the left or opposite leg. The pain was of insidious onset, and gradually but steadily increased in severity. On re-admission to the Neurosurgical Unit nine months after his first spinal operation, he exhibited slight generalized weakness of the left leg, marked limitation of straight-leg raising on that side, but not on the right side which was the side of former symptoms. The lumbar spine was rigid. As the earlier disk exploration had been right-sided only, it was presumed that a prolapse must have developed on the left side, as in some of our other cases. Re-exploration was therefore undertaken, but instead of the anticipated findings of disk prolapse those of spondylolisthesis at the lumbosacral junction were found instead. The left or remaining half of the fifth lumbar lamina was movable on the rest of its vertebra, while the vertebral body appeared to have slipped forwards ½ in. on the sacrum. The lumbosacral disk was not prolapsed and on curettage yielded little additional tissue. Immediate comparison of the recent with the original X-ray films confirmed the operative diagnosis of spondylolisthesis (*Fig.* 254). Accordingly an orthopædic colleague took over and performed a fusion operation to immobilize the lower three lumbar spines and the sacrum by means of both a tibial graft to the spines and a layer of bone chips dorsal to the laminæ.

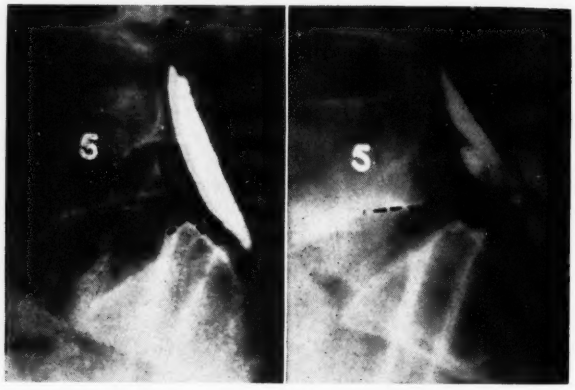


FIG. 254.—Radiographs of lumbosacral region during myelography in *Case* 96. A, Before first spinal operation, showing normal alinement of fifth lumbar body on sacrum; B, Before second spinal operation, showing fifth lumbar vertebral body displaced forwards ½ in. on sacrum.

For eight days his convalescence appeared promising, and then his left-sided sciatic pain came back again as severe as ever. Radiography of the grafted area did not disclose anything amiss, and as his manner was disgruntled, with outbursts of dyspnœa which seemed hysterical, he was regarded with considerable suspicion by us as well as by our psychiatric colleagues. Eventually after three months we were persuaded to re-operate, and at this third spinal operation we found that all the pieces of bone used in grafting were still loose. To our amazement, one fragment of bone had turned on edge, and its sharp point had pierced the first sacral nerve. All the graft fragments were removed.

We were all considerably chastened by this experience, but hoped that the patient would now respond. This he did to a certain extent, but he still complained of burning pain and weakness in the left leg and pain in the coccygeal region. As he was now able to get out of bed and walk, we adopted a conservative policy, encouraging him to get up and about. His symptoms, however, persisted, and seemed to have a causalgic quality. So after five more months his back was re-explored for the fourth time. After satisfying ourselves there was no recurrence of his disk prolapse, the posterior roots of the left fifth lumbar and first sacral nerves were divided intrathecally.

This operation, however, benefited him only temporarily. For about five weeks he was free of pain in his left leg, although his coccygeal pain continued. He exhibited slight sensory impairment in the territories of the fifth lumbar and first sacral nerve-roots on the left side, but his back remained rigid and there was marked limitation of straight-leg raising on both sides. He was discharged from hospital for a while. Before

long the left leg became painful again, and he exhibited once more a causalgia of that leg. Within the previously numbed zone, pin-prick caused an irritating, burning sensation, and the patient clamoured for narcotics to ease it. After much consideration with our psychiatric colleague, Dr. Harold Palmer, a right anterolateral chordotomy was performed opposite the seventh cervical vertebra, four months after the fourth operation.

This procedure, fortunately, was successful. It produced complete loss of pain and temperature sensibility on the left side below the third thoracic segmental level, and relieved him completely, not only of leg pain but of coccygeal pain as well. His convalescence was straightforward, and he walked out of hospital symptom-free at the end of three weeks.

This was the most intractable of all our cases of sciatica, largely because he developed a causalgia secondary to a penetrating injury of a nerve-root. For a while it looked as if he would be permanently disabled, and in all he underwent at our hands five major operative procedures, besides a fruitless sacro-iliac arthrodesis which he had undergone earlier. Fortunately he was relieved of the complicating causalgia by a chordotomy.

The initial lesion appears to have been a disk prolapse of intermittent type. The symptoms which this lesion caused were benefited by our first operation, and it is probably significant that he has never since complained of symptoms in his right leg. All the further troubles in his left leg were referable to the development of spondylolisthesis, and it is interesting to speculate why this complication came about. Our original radiographs indicate that there was an antecedent defect of the pars interarticularis of the neural arch of the fifth lumbar vertebra on the left side. This defect corresponds to descriptions given by Willis (1932), who found it in 5 per cent of skeletons, and, incidentally, it was demonstrated radiologically in two other cases of our series, once bilaterally and once unilaterally, but in neither was it associated with vertebral slipping. In this case, however, it seems likely that the hemilaminectomy carried out on the right side at our first operation must have interfered with the effective attachment of the neural arch to the rest of the vertebra, thus permitting the vertebral body to slip forwards.

It seems a perversity of fate that once troubles begin they continue in a chain. This patient should have been freed of symptoms after the spinal fusion operation, had not one of the bony fragments shifted and pierced an extrathecal nerve-root. Thereafter he was troubled by a causalgia, which like so many causalgias was not relieved by section of the afferent nerve-root proximal to the point of injury, but required division of the spinothalamic tract.

RECOGNITION OF OTHER LESIONS WHICH MAY SIMULATE DISK PROTRUSION

In the past many different conditions have been listed as common causes of sciatica and low-back pain, a view which is still widely held (Fletcher, 1947). Our experience is that prolapse of an intervertebral disk is responsible for most cases and that only infrequently do other conditions produce sciatica pain. In these respects our findings are in accord with those of several other workers (Dandy, 1941 and 1943; Hyndman, 1946; Young, 1946, a; etc.). Indeed we feel that some of the concepts which have been advanced to explain sciatica, such as "sciatic neuritis or radiculitis" of infective or gouty origin (Gowers, 1899), "sacroiliac strain" (Baer, 1917), "arthritis of spinal interarticular joints" (Putti, 1927), "contracture of the fascia lata" (Ober, 1935), and "hypertrophy of the ligamentum flavum" (Spurling, Mayfield, and Rogers, 1937), must be of rare occurrence as causes of sciatica, because we have not encountered at operation a single case which could not be adequately explained on more definite grounds.

Still, although disk protrusion is the only common cause of sciatica with or without low-back pain, any surgeon who undertakes disk surgery will encounter from time to time other lesions which simulate disk protrusion by producing these symptoms. While collecting our first 100 cases of disk protrusion we actually encountered only 2 such cases, although now we have experienced a number of lesions simulating disk protrusion. These can be grouped under the general headings of: (1) Tumours of the cauda equina; (2) Granulomatous disease of the intervertebral disk; (3) Tumours and other diseases affecting the spine; (4) Spondylolisthesis.

These various lesions all produce symptoms in a manner similar to that of a disk protrusion—namely, by involvement of one of the nerve-roots entering into the sciatic nerve. They will therefore be considered from the viewpoint of differential diagnosis and management. In addition we will consider a fifth group comprising certain conditions which are demonstrable radiologically, and which have sometimes been erroneously regarded as causes of sciatica.

1. Tumour of the Cauda Equina.—Tumours of the cauda equina commonly produce root-pain as their predominant symptom, and such features as motor, sensory, and sphincteric disturbances may not appear for months or years. Like sciatica due to disk protrusions, the radicular pain of a cauda equina tumour is aggravated by coughing, sneezing, and other sudden movements, and moreover is often associated with such signs as rigidity of the lumbar spine and limitation of straight-leg raising. The distribution of the pain of course depends upon which nerve-root is involved. When, however, the lower part of the cauda equina is involved, the pain may be that of sciatica, as in the following case.

Case G. K.—A nurse, aged 32 years, had for fourteen months complained of a stab-like pain in the right buttock extending down the back of the right thigh as far as the knee. This pain was produced by coughing and sneezing, and even by slight exertion. As time went by it increased gradually in frequency and severity, and at times would radiate also into the perineum. Examination disclosed a flat rigid lumbar spine, slight wasting of the right calf, hamstring, and buttock muscles, with weakness of ankle movements. The ankle-jerks were normal, but there was moderate limitation of straight-leg raising on both sides. Radiographs of the spine were normal. Lumbar puncture at the fourth space showed a clear cerebrospinal fluid under normal pressure with a normal Queckenstedt response. It contained 1 cell per 100 mm. and 80 mg. of protein per 100 c.c. Pantopaque myelography, however, disclosed a complete block which in the anteroposterior view seemed

opposite the lumbosacral disk space (*Fig.* 255). The prone-lateral view, however, indicated that the block was just below the level of this disk, while the opaque medium above the block had a concave lower border characteristic of an intrathecal tumour. At operation

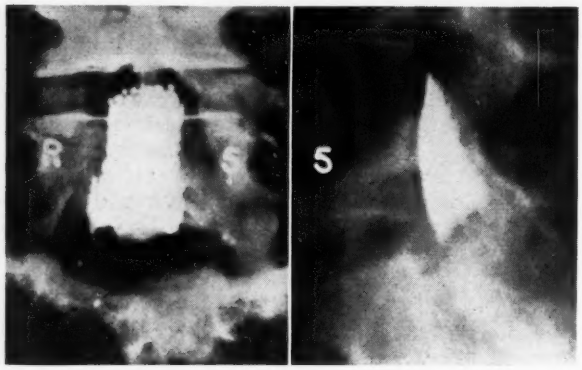


FIG. 255.—Myelograms in case of cauda equina tumour which clinically simulated disk prolapse (*see text*).

a neurofibroma attached to the second sacral nerve was found and removed, with complete relief of symptoms.

Love (1944, a), who has recorded a rich personal experience of cauda equina tumours simulating disk syndromes, including a series of 15 patients operated on during a period when 100 other patients were subjected to operation for protruded disk, believes that lumbar puncture is essential for the differentiation of these two groups of conditions. He considers that a value for the cerebrospinal fluid protein of more than 100 mg. per 100 c.c. usually indicates a neoplasm rather than a protruded lumbar disk. While we agree with the general principle behind this statement, we feel that no hard-and-fast figure of the spinal fluid protein can be taken as the dividing line for differential diagnosis, since we have observed a value as high as 180 mg. per 100 c.c. in a case of proved disk protrusion without a complete block, while in the tumour case reported above the value was only 80 mg. (It would of course have been higher had we been able to tap the theca below the tumour.) We would also agree with Love that myelography is most useful in distinguishing cauda equina tumours from protruded disks.

2. Granulomatous Disease of the Intervertebral Disk.—Usually tuberculous disease of the spine produces erosive changes in the bodies of the vertebræ readily discernible in plain radiographs of the spine, and therefore affording a clue to the correct diagnosis. We, however, have had two patients, neither of whom exhibited any radiological evidence of tuberculous disease of the vertebræ; yet in both at operation an intervertebral disk was found to be involved by a granulomatous process, which in one case was certainly of tuberculous origin, and in the other possibly so. As one patient died subsequently of miliary tuberculosis, these two cases will therefore be described in detail.

Case W. M.—A 64-year-old man had complained for six months of severe and continuous low-back pain which radiated around both buttocks to the fronts of both thighs. This pain was aggravated by coughing, sneezing, and other sudden movements, and had not been relieved by a month's complete bed-rest. There were no neurological signs in the lower limbs, but the lumbar spine was flat and rigid with tenderness at its mid-position. Radiographs of the spine showed diminution in width of the second lumbar space with a buttress of bone on the right side connecting the two vertebræ (*Fig.* 256). Lumbar puncture at the fourth lumbar level revealed a partial manometric block with a clear cerebrospinal fluid containing 10 cells and 60 mg. protein, while lipiodol myelography disclosed an almost complete block opposite the second lumbar disk. Radiographs of the chest were normal. A provisional diagnosis of disk prolapse at the second lumbar level was therefore made, and the bony buttressing of the space was interpreted as indicating that the disk lesion was of long standing. At operation the third lumbar spine and lamina were removed. The theca was opened, disclosing localized leptomeningeal adhesions and a backward prominence of the anterior wall of the theca. The second lumbar disk was then exposed on either side of the theca, when the backward prominence was found to consist partly of granulation tissue and partly of nucleus pulposus fragments, forming a ridge up to 0·6 cm. high by 1 cm. wide. The interior of the disk was then curetted from either side of the theca until bare bone was uncovered above and below the disk space. The bone was not eroded. On histological examination the granulation tissue was later found to show a non-specific chronic inflammatory reaction. Following operation the patient was kept resting in bed for six weeks, and when then allowed up he appeared much improved. When seen two years later he reported that he had suffered an attack of hæmatemesis but had felt only slight and occasional aches in his back. The lumbar spine was rigid, but was not tender. X-ray examination

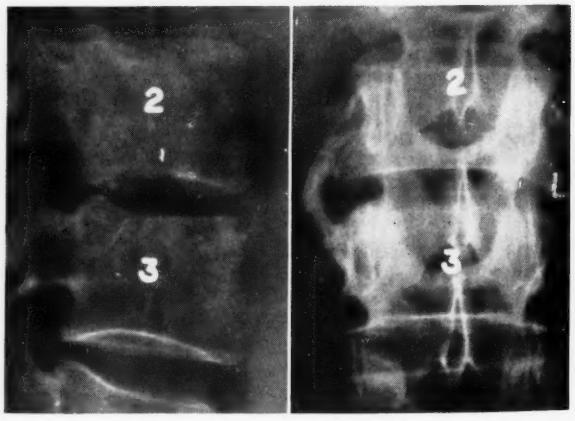


FIG. 256.—Radiographs of granulomatous disk before operation (*see text*). A, Lateral view shows narrowing of second lumbar disk space with notching of anterosuperior edge of third lumbar body; B, Anteroposterior view shows buttress of bone connecting the two vertebral bodies on the right side.

now showed that the disk space had collapsed, while the connecting buttress of bone on the right side had diminished slightly, suggesting that fusion of the opposing vertebral bodies had occurred (*Fig.* 257).

Case A. T.—A 30-year-old farm labourer, while driving a tractor six months before admission, had developed a severe attack of low-back pain which lasted a week. A month later, while again driving the tractor, the pain recurred, and by stages increased in severity. It did not respond to a long period of bed-rest. For one month prior to admission the pain extended down the front of the left thigh as well. Examination disclosed a healthy-looking young man with a marked and rigid scoliosis of the lumbar spine convex to the left side.

There was slight weakness of knee and ankle movements on the left side, but no alteration of tendon-jerks or limitation of straight-leg raising. The lumbar cerebrospinal fluid was normal and there was no manometric block. X rays disclosed slight narrowing of the third

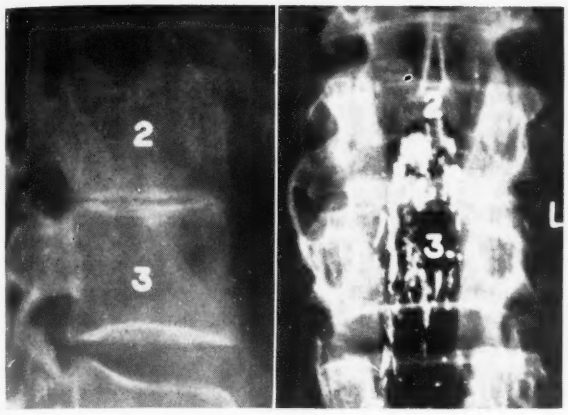
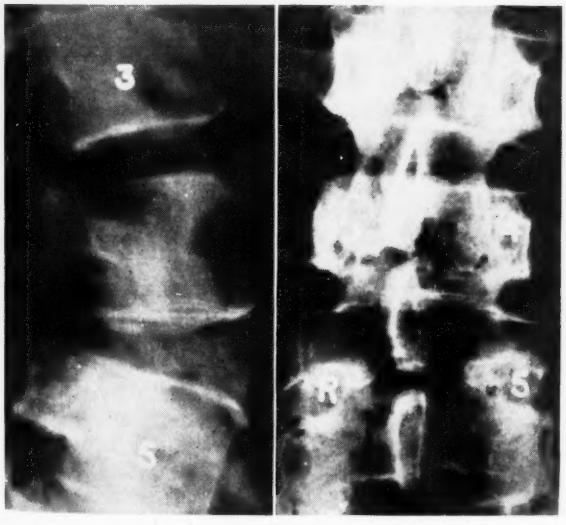


FIG. 257.—Radiographs of same case two years after operation. A, Lateral view shows further collapse of disk space; B, Anteroposterior view shows also that the bony buttress has regressed in size, suggesting that fusion has occurred between the two vertebral bodies. Globules of lipiodol are present within the theca at the level of operation.

lumbar disk space, but the bony structures appeared normal (*Fig.* 258), while pantopaque myelography disclosed an indentation of the thecal column opposite this disk space on the left side. A diagnosis of laterally-placed disk prolapse at this space was therefore made,



it being noted that the patient was afebrile, his blood-count and blood-sedimentation rate were normal, and his chest radiologically clear.

At operation a third lumbar laminectomy was performed, the theca being opened in the process. A large mass which appeared to be extruded disk material presented on the left side of the theca and was readily removed with the rongeurs. However, as the interior of the disk was being curetted, an area of bony erosion, a little over 1 cm. in diameter, was encountered on the upper surface of the body of the fourth lumbar vertebra (*Fig.* 258). This contained granulation tissue which later was shown on histological examination to contain tuberculous giant-cell systems. We had high hopes that the area of infection had been eradicated as in the previous case, but after operation he ran a low-grade continuous fever, and within three weeks had developed well-marked signs of tuberculous meningitis. He died twenty-nine days after operation. Post-mortem examination disclosed a generalized miliary process, as well as a tuberculous meningitis. The meningeal exudate was particularly marked among the roots of the cauda equina. It was interesting to note that even a post-mortem X-ray examination of the spine failed to disclose any bony lesion.

These two cases represent an important hazard of intervertebral disk surgery. The second case was definitely of tuberculous origin, and the first possibly so, although it might have been due to some other organism (Ghormley, Bickel, and Dickson, 1940). It is known that tuberculous disease of the spine commonly involves the intervertebral disks, although usually there is radiological evidence of erosion in the adjacent vertebral bodies. The fact that in both our cases the mid-lumbar disks were involved is probably fortuitous, and there seems to be no good reason why a like process could not involve the lower lumbar disks instead and cause sciatica. Incidentally, these two cases were the first cases of anterior crural pain due to mid-lumbar disk lesions explored in this Unit. We have since operated on cases of disk protrusion at these levels.

In the second case particularly, the pre-operative examinations gave us no inkling of the inflammatory nature of the disk lesion. It would seem then that in the course of a large experience of intervertebral

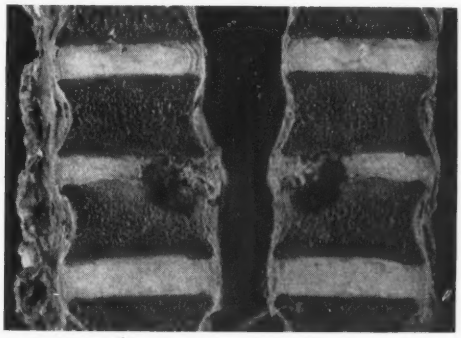


FIG. 258.—Left, radiographs of *Case* A. T. before operation, showing slight narrowing of third lumbar disk space, but no obvious bony lesion. Above, coronal section through spine at post-mortem shows focus of bony erosion in third lumbar vertebra, not revealed by X rays.

disk surgery, a surgeon must invariably encounter an occasional case of this sort. In most instances no harm will follow surgical intervention, as in the first case, but every now and then a miliary tuberculosis will result, as in our second case. This second case represents our only post-operative fatality in the course of more than 300 operations for disk prolapses at various levels of the spine. It is, of course, preferable not to open the theca in cases of this sort, as we did in both our cases before we had ascertained the real nature of the disk lesion.

3. Tumours and Other Diseases affecting the Spine.—Any disease process which is so placed in the spine that it can compress an emerging extra-thecal nerve-root may give rise to symptoms which

simulate a disk protrusion. We have seen sciatica caused by such lesions as osteochondroma of the lamina of the fourth lumbar vertebra (relieved by removal of tumour), osteitis deformans affecting the lumbar spine, sacrum, and pelvis (relieved by bilateral thoracic chordotomy), secondary carcinoma of the ileum, and by an extrathecal hydatid cyst arising from the sacrum. With the exception of the hydatid cyst all were recognizable by plain radiography. The last case is probably unique, even in countries where echinococcus infestations are endemic, and as the plain radiographs of the spine appeared normal and the history was very suggestive of a disk lesion, it will be reported separately.

Case D. R—s.—A female, aged 20 years, had experienced during the preceding eighteen months intermittent attacks of disabling pain in the lower back and posterior aspect of the right leg, each of several weeks' duration. Each attack had been induced by trauma, while in the

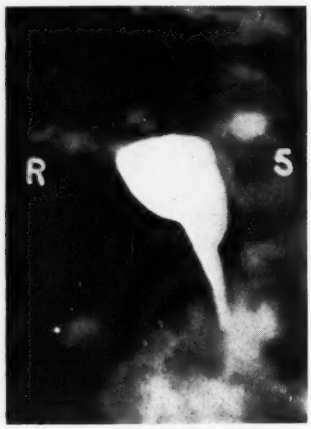


FIG. 259.—Myelogram showing distorsion of lower end of thecal column by a large extrathecal tumour which was later found to be an hydatid cyst (*see text*).

first attack the low-back pain had even preceded the development of sciatica by ten days. The pain, moreover, was aggravated by coughing and sneezing, and in between attacks disappeared completely. The attack which led to her admission had disabled her for five months and showed no signs of abatement. Shortly after its onset she had noticed numbness down the back of the right leg. Examination disclosed a flat and rigid lumbar spine, moderate wasting of the right buttock, hamstring, and calf muscles, and definite weakness of ankle movements, flexion of the knee, and extension of the hip. The right ankle-jerk was diminished, and there was marked limitation of straight-leg raising on that side. Sensory testing revealed complete analgesia and anæsthesia of the posterior aspect of the right leg and the right half of the perineum (all sacral segments in right side). Radiographs of the spinal column, sacrum, and pelvis appeared normal. The lumbar cerebrospinal fluid contained 10 cells per c.mm. and 40 mg. of protein per 100 c.c. Myelography showed a gross indentation of the sacral theca on the left side indicating a large extrathecal tumour (*Fig.* 259). At operation this tumour was found to be a single hydatid cyst (5 cm. long by 3 cm. diameter) arising in the body of the second piece of the sacrum and projecting into the extrathecal space. Pain was completely relieved by its removal, although sensory loss persisted. It may be noted in passing that the hydatid complement-fixation test was negative at the time of operation.

This case is important not only from the viewpoint of differential diagnosis of disk protrusion, but also because it illustrates an important feature of the pathogenesis of sciatica. Although outside the scope of this paper, we might mention here that we have evidence suggesting that, in cases of sciatica due to disk protrusion, the sudden onset or spontaneous disappearance of symptoms is not necessarily due to the advent or recession of a disk protrusion, but rather to changes occurring within the nerve-root straddling the protrusion. Indeed the disk protrusion not only may have been present for some time prior to the onset of symptoms, but also it may not alter in size or position when symptoms either appear or pass away. In this particular case of hydatid cyst the symptoms were on each occasion ushered in by a fall, but as the hydatid cyst was entirely surrounded by bony structures it is most unlikely that these falls could have affected it. Moreover the negative hydatid complement-fixation test and the absence of any urticarial manifestations in the history indicate that hydatid fluid had never leaked into the host's tissues, as would be expected if the thin-walled cyst had been subjected to any appreciable strain. Therefore, as the hydatid cyst itself was undoubtedly not affected by the falls, we can presume that the appearance of symptoms after each fall must have been provoked by changes in the nerve-roots straddling the cyst. These changes will be discussed in a later communication.

4. Spondylolisthesis.—Spondylolisthesis is always described as one of the causes of sciatica, although it must be an uncommon cause, for we have encountered at operation only one case with sciatic symptoms, and then the circumstances were most unusual (*Case* 96, p. 236). Most cases of spondylolisthesis with symptoms present low-back pain, and only about 10 per cent are associated with sciatica (Meyerding, 1943). Meyerding (1941) has pointed out that the forward slipping of a vertebral body tends rather to give a nerve-root increased room than to compress it, and both he and Dandy (1945) consider that nerve-root compression is due instead to an associated disk protrusion. Thus Meyerding diagnosed disk protrusion at the level of slipping in 15 out of 25 cases in which spondylolisthesis was associated with sciatica, and this diagnosis was subsequently confirmed in 6 cases submitted to operation. He advocated an operative procedure combining removal of the offending protrusion with fusion of the lower three lumbar spines and the sacrum. Dandy took a more advanced view, and reported that in a series of 20 cases with leg pain he had found disk protrusions in each instance, and indeed more than one disk protrusion in 18 of them. It was his impression that usually the disk protrusion at the level of slipping was not responsible for symptoms so much as the protrusions at more cephalic levels which were often of the concealed type. He felt that spinal fusion by bone-graft was unnecessary, and that a thorough curettage of the affected intervertebral disks alone would suffice to produce fibrous ankylosis between adjacent vertebral bodies.

Certain Conditions demonstrable radiologically, and sometimes erroneously regarded as Causes of Sciatica.—At some period or other

a number of anomalies and acquired abnormalities of the spine, readily demonstrated by X-ray examination, have been considered as causes of sciatica and low-back pain. In actual fact, however, they are either incidental findings or else are really secondary manifestations. As there is still some confusion of thought regarding them, we shall consider them briefly.

Spina bifida occulta and sacralization of the lower lumbar vertebra are two such anomalies. In sacralization, for instance, some have postulated that nerve-roots are compressed by the fusing process occurring between the transitional vertebra and the sacrum. These anomalies, however, are of frequent occurrence, and in most people are not accompanied by symptoms. Brailsford (1929) found on radiological examination that spina bifida occulta affected either the fifth lumbar or first sacral vertebra in 11 per cent of more than 3000 persons without particular disability of the spine, while sacralization occurred in 8 per cent. Others have given similar statistics. It is not surprising therefore that in our series spina bifida occulta was present in 5 patients, and sacralization, either partial or complete, in 9 patients. These statistics suggest that these anomalies do not render those who possess them any more liable to sciatica or low-back pain than other people. The radiological demonstration of either of these anomalies in a patient with symptoms should therefore be regarded as only an incidental finding. In our experience the level of the deficient vertebra in spina bifida occulta has had no relation to the level of the prolapsed disk, but where sacralization is present the disk prolapse has invariably been present at the disk immediately cephalic to the transitional segment. A similar finding has been recorded by others (Childe, 1945; Gillespie, 1946). It is our belief that the fusing process stabilizes and protects the narrow lumbosacral disk, which therefore cannot prolapse. There remains then the fourth disk alone as the site for a disk protrusion likely to cause persistent and disabling sciatic pain.

Interarticular arthritis and sacro-iliac arthritis have both been advanced as causes of sciatica. Although arthritic changes in the interlaminar joints might be expected to follow the diminution in width of the intervertebral space so often encountered in disk protrusion, in this series only one patient showed definite radiographic evidence of such a condition. Oblique views, however, were not taken as a routine, otherwise these arthritic changes might have been revealed more often. Only two patients exhibited radiographic appearances in the sacro-iliac joints which could definitely be considered as pathological. It is interesting that in one of these two cases, a war pensioner, the sacro-iliac change was strictly unilateral and was confined to the side opposite to that of symptoms. Yet this patient had been officially listed as suffering from sacro-iliac disease. In both cases symptoms were relieved by removal of disk protrusions.

COMPLICATIONS OF INTERVERTEBRAL DISK OPERATIONS

Intervertebral disk operations are of course liable to the same complications as other major surgical procedures. These include wound infections, femoral vein thrombosis, pulmonary infections, and so forth. There are, however, some complications which are peculiar to these operative procedures, and which consequently deserve mention.

1. Extrathecal Leakage of Cerebrospinal Fluid.—This complication produced symptoms in 2 patients in this series. If the dura has been opened, cerebrospinal fluid may leak through a point on the sutured incision and form a reservoir of fluid in the dead space between muscles and theca left by removal of the laminæ. No symptoms, however, usually appear unless this reservoir in its turn leaks through a narrow channel in the muscle layer to form another collection of fluid under the subcutaneous tissues. The patient then complains of headache whenever his head is elevated, and simultaneously a palpable bag of cerebrospinal fluid collects beneath the subcutaneous tissues. Headache passes off again once the patient's head is lowered. Such symptoms usually appear during the second week after operation, and are due to intracranial hypotension occasioned by the passage of cerebrospinal fluid out of the subarachnoid space. Treatment consists of nursing the patient with his head low and his feet elevated. Generally the sinus through the muscles closes within a few days, as it did in both cases in this series. Occasionally, however, it is necessary to reopen part of the laminectomy incision and close the fistulous opening in the theca with a stitch, reinforced by a muscle stamp. Relief of the postural headache has always promptly followed this procedure.

2. Rarer Complications.—

a. Spondylolisthesis.—One example of this has occurred in our experience of more than 300 operated cases, and has been described (*Case* 96, p. 236).

b. Causalgia.—In the above patient this complication also supervened, as a result of a penetrating injury to a nerve-root. Eventually the pain was completely relieved by a chordotomy. We have since had another case of causalgia, this time following an apparently straightforward disk operation, but this case was relieved only partially by a chordotomy. We have little idea how frequent or how rare this complication may be, but note that Freeman and Watts (1946) have described a case of what seems to have been causalgia following a disk operation, which they treated by prefrontal leucotomy with some clinical improvement.

c. Acute Post-operative Aseptic Leptomeningitis.—In our experience this complication has occurred once in over 300 laminectomies for disk prolapse. Starting about five weeks after operation the patient had two bouts of fever, stiff neck, and headache, each lasting a few days. The first bout was the most severe, and during it a lumbar puncture showed a hazy cerebrospinal fluid containing 1400 white cells (50 per cent polymorphonuclears) per c. mm. and 200 mg. or protein per 100 c.c. The condition subsided spontaneously, and we presume was due to the leakage of liquefied and disintegrating products of an extrathecal hæmatoma through a fistulous hole in the dura into the subarachnoid space. This condition has been described by Finlayson and Penfield (1941).

d. Injury to the Aorta and Inferior Vena Cava.—We have fortunately not encountered this complication, although we have heard of a fatality on the operating table resulting from damage to the aorta due to penetration of the anterior part of the annulus fibrosus by a sharp instrument used in curetting the interior of the disk. That complications of this type do occur on occasions is naïvely indicated by the report of Linton and White (1945) of the successful cure by operation of an arteriovenous fistula between the right common iliac artery and the inferior vena cava, which followed an operation for ruptured intervertebral disk at the fourth lumbar level. These authors also mention having heard of three other similar cases.

e. Paralysis of Cauda Equina.—It goes without saying that during operation the extrathecal nerve-roots must be treated with care, and not stretched unduly during retraction. Otherwise troublesome pareses may occur, particularly of the calf and anterior tibial muscles. We unfortunately encountered these in three cases in this series which were explored for a second time, and though these improved somewhat as months went by, the degree of weakness still is appreciable. In two cases where the fifth lumbar nerve-root was involved, the pareses took the form of partial foot-drop, while in one case where the first sacral nerve was involved, gross weakness of plantar flexion, so that the patient was unable to rise on his toes, became manifest.

RESULTS OF TREATMENT

All cases in this particular series suffered from sciatica and/or low-back pain. Two cases of sciatica were complicated by foot-drop, but there were no instances of such lumbar intervertebral disk syndromes as anterior crural pain associated with protrusion of the third lumbar disk (Spurling and Grantham, 1940) or complete cauda equina paralysis (Falconer, 1944), although we have encountered both these symptoms at other times. Intervertebral disk lesions were demonstrated at operation in all except one patient, and in retrospect we now feel that in him an intervertebral disk lesion was overlooked.

There were no operative deaths, and all patients have been traced for periods ranging from one to four years, and have been examined personally by one of us at least once after discharge from hospital. In order to obtain an unbiased assessment of the results, we posted a questionnaire to each patient twelve months after the last patient in the series had undergone operation. In this questionnaire we sought information as to the presence of residual leg and low-back pain, together with any return of symptoms, transient or permanent, and any residual disability. Patients were invited also to describe their present work and recreational activities, and to assess the present state compared with that prior to operation (*Table I*). This assessment of results by the patients themselves seemed less open to criticism of bias than if we ourselves had graded them. With few exceptions the patients' replies agreed with our own personal opinions.

Ninety-three patients replied to this questionnaire and 7 did not. Two of these 7 had died four and five months after operation of sudden cardiac failure and acute nephritis respectively, but both had been relieved of their disk symptoms. The remaining 5 patients who did not reply were all ex-servicemen, and we learnt indirectly that 2 of them were cured, 2 still had persistent symptoms (in one instance down the opposite leg) but were still performing their work full time, and that only 1 was appreciably disabled. We thus have progress information concerning all our patients.

Table I.—Extract from Questionnaire sent to each Patient, showing Method of Assessment of Disability

Section E. How would you Assess your State before Operation and now according to the following Classification? Please put an X in each Column opposite the Description which Fits your Case.	Before Operation	Now
a. Bedridden		
b. Out of bed, but unable to move from home or hospital		
c. Able to walk short distances, but do no work		
d. Able at times to perform light work, or light household duties		
e. Able to perform continuously light work or light household duties		
f. Able to do full work or full household duties, but with slight discomfort		
g. Completely free of symptoms		

It is known that, although sciatica and low-back pain commonly occur together, their symptoms are produced in different ways (Dandy, 1943; Hyndman, 1946; Young, 1946, a; etc.). It appears that a disk protrusion of itself can produce low-back pain, but that sciatica is due to compression extrathecally of a nerve-root, usually either the fifth lumbar or the first sacral. As our own observations on symptom-production, which will be reported later, are in keeping with this view-point, we have divided our cases into two groups, a larger group of cases where sciatica predominated, and a smaller group of cases where low-back pain predominated.

1. Results in Cases of Sciatica.—There were 77 cases in this group including the two cases which had died at home of intercurrent disease. Of the 75 surviving patients we learnt from various sources that good results were obtained in 54 (72 per cent), all of whom returned to work with little or no disability, fair results were obtained in a further 17 (23 per cent) who were engaged full time in light work, and poor results were obtained in 4 (5 per cent) who worked only intermittently or not at all. Even these last patients, however, seemed improved on their pre-operative status, as will be discussed later.

Of these 77 patients 10 had complained of sciatica alone, and the remainder at some stage of low-back pain as well. Fifty-four were males and 23 females, the youngest being 16 years old at the time of operation and the oldest 60 years. Three patients were under the age of 20 years, 19 between

20 and 29 years, 29 between 30 and 39 years, 21 between 40 and 49 years, 4 between 50 and 59 years, and 1 was 60 years old. In all these patients disk lesions were demonstrated at operation, multiple lesions being dealt with in 16 cases.

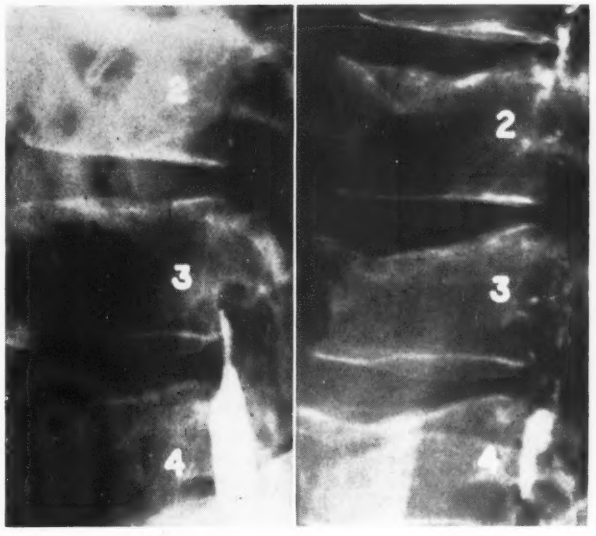
In order to gain a wider perspective of the results of surgical treatment, we analysed the replies of the 73 patients in this group who answered the questionnaire. *Table II*, which sets out the results of treatment, as assessed by the patients themselves, shows that the majority reported considerable benefit: 36 per cent of patients described themselves as completely cured, and a further 36 per cent as working full time but with slight discomfort. This makes 72 per cent of good results. A further 23 per cent reported that they were now engaged in light work continuously. Only 4 (5 per cent) were not working regularly, although 2 of these did concede some improvement on their pre-operative state. We actually feel that all four were benefited. Two were servicemen of World War I both pensioned for more than twenty years for chronic sciatica; both were relieved of leg pain but continued to complain instead of other things and to draw their pensions. The third was a serviceman of World War II, also in receipt of a pension, who, after having been improved for a while, had developed recurrent symptoms. The fourth was a compensation case, who after having experienced for three years right-sided sciatica with well-marked signs consequent upon a fall at his work, had a disk protrusion removed and returned to work symptom-free. He then had another fall at work, developing again troublesome symptoms, particularly of coccygeal pain, and was not benefited by a further spinal operation at which the operative findings were indefinite. In *Table II* it will also be noticed that one patient described herself as little disabled before operation and as still in the same state afterwards. We feel her memory was short, for our records show that before operation she had been unable to carry on her work, which she now does without undue difficulty.

As regards occupations, we learnt that 46 (64 per cent of group) had returned to their former work or one of equivalent physical status, that 5 (7 per cent) had engaged in work of even more strenuous character, that 17 (24 per cent) had taken up lighter work. Of these 68 patients who were working continuously, 19 could be classified as engaged in heavy manual work, 31 in work of moderate physical severity, and 18 in light work.

A particularly noteworthy result was achieved in a 60-year-old electric linesman (*Case* 7), the oldest patient in our series. Some eight months after laminectomy and curettage of both lower lumbar disks, he fell 14 ft. off a transformer platform, sustaining compression fractures of the second, third, and fourth lumbar vertebræ (*Fig.* 260) but not a recurrence of leg pain. He was immobilized in a plaster jacket for four months, and was then able to return to his work, still free of his former symptoms, and without limitation of straight-leg raising on either side.

Table II.—Analysis of Replies of 73 Patients with Sciatica, comparing Severity of Disability before Operation with any Disability remaining afterwards

Disability before Operation		Disability after Operation				
Severity	Number in Group	*c.* Walking, but not Working	*d.* Intermittent Light Work	*e.* Continuous Light Work	*f.* Full Work, Slight Discomfort	*g.* No Discomfort
a. Bedridden	14	—	1	2	4	7
a–c	9 (24)	1	—	2	4	2
a–f	1	—	—	—	—	1
b. Confined to house	10	—	—	5	3	2
b–c	3 (13)	—	—	1	1	1
c. Walking, but not working	18	1	1	5	5	6
c–f	1 (19)	—	—	—	—	1
d. Intermittent light work	9	—	—	2	6	1
e. Continuous light work	7	—	—	—	2	5
f. Full work, but slight discomfort	1	—	—	—	1	—
Totals	73	2 (3 per cent)	2 (3 per cent)	17 (23 per cent)	26 (36 per cent)	26 (36 per cent)



A B

Fig. 260.—Radiographs of *Case* 7. A, Before operation, showing normal vertebral bodies; B, One year after operation, showing compression fractures of second, third, and fourth lumbar bodies sustained four months previously. There was no return of 'disk' symptoms (*see text*).

In addition to assessing their disability, each patient was asked in the questionnaire to record the presence of any residual sciatica or low-back symptoms. A summary of replies is listed in *Table III*, which shows that while 41 per cent had been relieved completely of these symptoms, 59 per cent were still conscious of some of their former symptoms, although in most instances they were slight and intermittent. It was interesting to note that 6 patients, who described themselves as cured, had experienced a transitory return of sciatic pain at periods varying from two to twelve months after leaving hospital. However, two of these, seen by us during the period of temporary discomfort, did not exhibit such signs as limitation of straight-leg raising or rigidity of the lumbar spine, which had characterized their pre-operative attacks.

Table III.—Residual Symptoms in 73 Cases of Sciatica

No Symptoms	Intermittent Only			Continuous		
	Both Sciatica and Low-back Pain	Sciatica Only	Low-back Pain Only	Both Sciatica and Low-back Pain	Sciatica Only	Low-back Pain Only
30	16	8	11	5	1	2
41 per cent	48 per cent			11 per cent		

We also assessed for each patient replying to the questionnaire the duration of symptoms and disability before operation (*Table IV*), as well as the time taken subsequently for return to work (*Table V*). *Table IV* shows that in most instances symptoms had been present for a considerable time. Thus 37 patients (51 per cent) had complained of sciatica, intermittent or continuous, for more than a year, while 10 (14 per cent) had been completely disabled for at least the same period. This illustrates how severe an economic handicap sciatica may be. After operation some months are usually required for convalescence (*Table V*). Operation, therefore, should never be regarded as a procedure offering speedy relief. The length of convalescence is roughly proportional to the physical demands of a man's occupation, and with a few exceptions bears little relationship to the duration of symptoms

Table IV.—Duration of Disability before Operation in 73 Patients with Sciatica

	Number of Patients in Group	Over 20 Years	11–20 Years	6–10 Years	2–5 Years	13–24 Months	7–12 Months	1–6 Months	Under 1 Month
Duration of sciatica	73	3	1	8	15	10	19	15	2
Duration of low-back pain	63	6	6	14	11	7	8	9	2
Aggregate time lost from work	73	—	2	—	2	6	25	30	8

Table V.—Time Taken after Operation before Return to Work in 73 Cases of Sciatica

	Cases
Under 3 months	7
3 months	16
4 to 5 months	34
6 to 8 months	12
9 to 12 months	2
Not returned to work	2
Total	73

Table VI.—Analysis of Replies of 20 Patients with Low-back Pain, comparing Severity of Disability before Operation with any Disability remaining Afterwards

Disability before Operation		Disability after Operation				
Severity	Number in Group	*c.* Walking, but not Working	*d.* Intermittent Light Work	*e.* Continuous Light Work	*f.* Full Work, but Slight Discomfort	*g.* No Discomfort
a. Bedriddridden	2	—	—	—	1	1
a–c	1 (4)	—	—	—	—	1
a–e	1	—	—	—	—	1
b. Confined to house	2	—	—	—	—	2
c. Walking, but not working	2 (4)	1	—	1	—	—
c–e	2	—	—	—	1	1
d. Intermittent light work	6	—	—	2	3	1
e. Continuous light work	3	—	—	—	3	—
f. Full work, but slight discomfort	1	—	—	1	—	—
Totals	20	1 (5 per cent)	—	4 (20 per cent)	8 (40 per cent)	7 (35 per cent)

beforehand. Thus, whereas patients engaged in sedentary occupations usually take from three to four months to return to work, those engaged in heavy work may require six months or longer.

These long convalescent periods may involve a working man in severe financial strain, although in this country the hardships of a long convalescence are mitigated by social security payments, and this may have had some effect on our figures. Furthermore, with one exception we were not particularly concerned in our patients with problems of compensation or of litigation, and in this respect our series again differs from several described in the literature. Some 18 patients were servicemen or war pensioners, most of whom had been invalided home from overseas because of sciatica or low-back pain, but we were not faced with the problem of returning them to active service but only with fitting them for civil life. We feel that the results of treatment in this group of servicemen differ little from those in the remainder of our patients.

2. Results in Cases of Low-Back Pain.—There were 23 patients in this group, all surviving at the time of follow-up. Good results were obtained in 15 (65 per cent) who returned to full work with little or no disability, fair results were obtained in 6 patients (26 per cent) who returned to light work continuously, and poor results were obtained in 2 (9 per cent) who were not improved and did not return to work.

Of these 23 patients 10 had complained of low-back pain alone, while 13 at some stage had also experienced pain down one leg, although at the time of operation leg pain was inconspicuous. Nineteen were males and 4 were females, the youngest being 21 years at the time of operation and the oldest 53 years. Ten were in the third decade of life, 6 in the fourth, 5 in the fifth, and 2 in the sixth. Disk lesions were found and curetted in 21 of these patients, a total of 29 pathological disks being dealt with. In 1 patient a scarred disk was demonstrated, but at that period of our experience its significance was not realized, and so the lesion was treated by spinal fusion alone, with however some improvement. In the remaining patient no disk lesion was identified, and although this patient had his spine fused, he was not benefited.

Twenty patients replied to the questionnaire, and their assessment of results is set out in *Table VI*. Thirty-five per cent reported that they were completely symptom-free, and an additional 40 per cent were performing full work though with slight discomfort, while a further 20 per cent were undertaking light work continuously. It will be noticed that one patient in this latter group described himself as actually more disabled after operation than before; our records, however, indicate he was bedridden at the time of operation. Only one patient described himself as a failure, and we do not know why this was so, as before operation the clinical features had seemed definite and the myelogram had been positive, while at operation his disk lesion had been adequately dealt with, as was confirmed at a second exploration. In addition to this failure we know that there was also one failure among the 3 patients with low-back pain who did not reply to the questionnaire. This was the patient whose spine had been fused without a disk lesion having been identified. A second operation was advised but was declined.

As regards occupations, 12 had returned to their former work or one of equivalent physical status, 7 had sought lighter work, and only 1 was not working. The occupations could be classified as heavy in 3 instances, as of moderate severity in 12,

Table VII.—Duration of Disability before Operation in 20 Patients with Low-back Pain

	Number of Patients in Group	Over 20 Years	11–20 Years	6–20 Years	2–5 Years	13–24 Months	7–12 Months	1–6 Months	Under 1 Month
Duration of sciatica	20	—	6	4	5	1	1	2	1
Duration of low-back pain	12	—	1	3	2	—	3	2	1
Aggregate time lost from work	20	—	—	—	3*	4	6	6	1

* One patient has also pulmonary tuberculosis, and this was principally responsible for the time lost from work.

Table VIII.—Time taken after Operation before Return to Work in 20 Cases of Low-back Pain

	Cases
Under 3 months	2
3 months	2
4 to 5 months	5
6 to 8 months	9
9 to 12 months	1
Not returned to work	1
Total	20

Table IX.—Residual Symptoms in 20 Cases of Low-back Pain

No Symptoms	Intermittent			Continuous		
	Both Sciatica and Low-back Pain	Sciatica Only	Low-back Pain Only	Both Sciatica and Low-back Pain	Sciatica Only	Low-back Pain Only
9	5	1	2	—	1	2
45 per cent	40 per cent			15 per cent		

and as light in 4 instances. The duration of symptoms and disability before operation was also assessed, and the length of convalescence afterwards. In addition the presence of any residual symptoms was recorded. The findings (*Tables VII–IX*) are similar to those of the sciatica group, in that most patients had had a long period of symptoms and disability pre-operatively. Even allowing for the prolonged convalescence required after spinal fusion, a longer period was required for convalescence, for, whereas most cases of sciatica were able to return to work within six months, half of our cases of low-back pain required from six to twelve months. It was interesting to note that a few patients complained after operation of a weak and tired back for many months, but eventually became symptom-free.

One result was particularly noteworthy. It concerned a 27-year-old bushman (*Case* 10), who, six years before, had been laid low with a sudden attack of left-sided sciatica while actually engaged in a tree-felling contest. He had been immobilized on a Bradford frame for seventeen months before returning to work, and after that had suffered many recurrent attacks of severe low-back pain, being incapacitated on an average for three months every year. At operation a disk prolapse at the fourth lumbar level was found associated with meningitis serosa circumscripta, and was removed. Subsequently, in spite of a medical injunction, he returned to his former activities, and within two years had become the reigning champion axeman of New Zealand's principal timber province.

3. Further Comments.—At the original operations interlaminar explorations were employed on 39 occasions and laminectomies on 61. Later, however, 5 patients who had undergone an interlaminar exploration previously, were submitted to a second operation, this time a lamina being removed. As far as we can judge, there is no intrinsic difference in the late results of the two groups, and the removal of one or two spines and laminæ does not appreciably increase convalescence or provoke persistent symptoms afterwards.

In 99 patients a total of 123 pathological disks were identified, multiple lesions occurring in 24 patients (24 per cent). The lesions included 67 cases of disk projection, 16 cases of extruded disk, 7 cases of scarred disk, and 33 cases of intermittent prolapse. With one exception, a scarred disk which was bone-grafted, all these disk prolapses were curetted, and the results of operation appear similar in each group. We have specially analysed the results in the 11 cases where only prolapses of the intermittent type were found (*Table X*), and found that they were as satisfactory as in the other groups.

When we first accepted for operation patients with severe low-back pain, but without sciatica, we arranged with our orthopædic colleagues that in addition to any local procedure done on the disk, each alternate patient should have a spinal fusion performed. In this way we hoped to obtain controls on our results. Some 5 patients accordingly had their spines fused with an Albee graft, including the patient with the negative exploration and the patient with the scarred disk which otherwise was left undisturbed, but we soon discontinued bone-grafting when we compared the results with those not so treated. Of the 5 cases that were bone-grafted only 1 secured a good result, and 1 a fair result without further operation, although in the second of these two successes recent radiographs suggest that the bone-graft has not united properly with the spine. Two of the 5 were later submitted to a second operation, and in both the graft was found to be ununited at one end of its bed. One of these cases, however, was cured after the curettage of the affected disk was completed from the other side of the theca. Consequently in at least three of the five cases the graft failed to become properly incorporated across the affected disk-space. Comparing the two groups —those that were fused and those that were not— it seemed that convalescence was smoother in the second group, and of course much more rapid, because a long period of three to four months' immobilization after the operation was not required. We have had no experience of other methods of immobilization, such as that of Briggs and Milligan (1944), who perform a disk removal through a partial fifth lumbar laminectomy, and then fix the lumbosacral articulation by performing a facetectomy of the interarticular joints and then filling in the space dorsal to the theca with bone-chips.

It is difficult from their writings to determine the consensus of opinion among neurosurgeons as to the necessity or frequency with which spinal fusions should be carried out, although orthopædic surgeons appear to favour it. Certainly in the earlier part of the decade some neurosurgeons, when

Table X.—Analysis of Replies of 11 Patients, in whom only Disk Prolapses of the Intermittent Type were dealt with at Operation, comparing Severity of Pre-operative Disability with any Disability remaining afterwards

Disability before Operation		Disability after Operation				
Severity	Number in Group	*c.* Walking, but not Working	*d.* Intermittent Light Work	*e.* Continuous Light Work	*f.* Full Work, but Slight Discomfort	*g.* No Discomfort
a. Bedridden	2	—	—	—	1	1
b. Confined to house	1	—	—	1	—	—
c. Walking, but not working	3	—	—	2	—	1
d. Intermittent light work	4	—	—	2	2	—
e. Continuous light work	1	—	—	—	—	1
Totals	11	—	—	5 (46 per cent)	3 (27 per cent)	3 (27 per cent)

writing jointly with their orthopædic colleagues (Barr and Mixter, 1941; Ghormley, Love, and Young, 1942), advocated a "combined operation" in an appreciable proportion of cases. Recently, however, these neurosurgeons appear to have modified their views (Love, 1944, b; Mixter, 1945). In our experience spinal fusion is rarely required.

Finally in this series were 2 cases with foot-drop following sciatica. Both were found at operation to have disk lesions which had caused an apparently complete 'block' of the fifth lumbar nerve-root, and both over the course of two years have since shown a slight but definite improvement of motor power. These two cases, however, illustrate a problem which is outside the scope of this paper, and will be left till a later communication.

DISCUSSION

Our findings show clearly that lumbar intervertebral disk lesions are the only common cause of severe and intractable sciatica, are a common cause of severe and intractable low-back pain, and also that the results of their surgical treatment can be reasonably successful.

Our series of cases of sciatica differs from most reported in the literature in the absence of negative explorations. With the notable exceptions of Dandy (1943) and of Clarke (1946), neither of whom appear to have published their results in detail, most surgeons appear to have made negative explorations in a high proportion of cases (Verbugghen, 1943; Grant, 1944 and 1946; Shinners and Hamby, 1944; Krayenbühl and Weber, 1945; Munro, 1945; Holmes and Sworn, 1946; etc.). This proportion has been recorded as more than a third and has frequently ranged from a fifth to a quarter of all cases. Several surgeons have drawn attention to the similarity of clinical features between their cases with positive findings and their cases with negative findings, without being able to account for the difference in operative appearances (Krayenbühl and Weber, 1945; Munro, 1945). We believe that the explanation lies in failure to recognize and to deal with that type of disk protrusion, which Dandy described as 'concealed', but which we prefer to term 'intermittent'. Our observations have shown that the results of operation in this type of prolapse can be as satisfactory as in the other types.

That lumbar intervertebral disk protrusions are the only common cause of severe and intractable sciatica is shown by the analyses of our 77 cases of chronic sciatica submitted to operation. They were selected for operation solely because their symptoms were disabling and persistent, and during this period only two other cases of apparently severe and intractable sciatica passed through our hands, both of which had distinctive features indicating tumour of the cauda equina or spine. Consequently the facts that in each of these 77 cases disk lesions were found and dealt with, that no other type of lesion was found in the majority of cases, and that all patients were benefited in varying degrees, surely prove that disk lesions are the common cause of severe and intractable sciatica. In a larger experience we have encountered other causes, such as tumours of the cauda equina and the spinal column, and inflammatory diseases of the intervertebral disks, but such causes are uncommon. We have not yet encountered a case which could be shown to be due to a primary neuritis, to strain or disease of the sacro-iliac joints, or to disease of the spinal interarticular joints, all explanations of sciatica which have been popular in the past.

That lumbar disk lesions are also a common cause of low-back pain is shown not only by the fact that severe backache was relieved or improved in most cases where it was associated with sciatica, but also by our observations in the group of 23 cases of severe low-back pain submitted to surgery. This group, however, was highly selected, because in addition to symptoms of severe and persistent character, marked physical signs, and, with one exception, a positive myelogram, were required by us before submitting these patients to operation. Consequently the group is not strictly representative of the great mass of sufferers from chronic backache. But the facts that disk lesions were demonstrated in 22 of these 23 patients, and that 21 patients were appreciably benefited, indicates that lumbar disk lesions are at least a common cause of severe and intractable low-back pain. Baker and Soniat (1940), Dandy (1944), and Young (1946, b) have reported cases of pure low-back pain relieved by disk operation, but none have previously described detailed results in a group of cases.

Our operative results, taken as a whole, are similar to those of many other surgeons after positive explorations for disk projection (Verbugghen, 1943; Grant, 1944 and 1946; Shinners and Hamby, 1944; Krayenbühl and Weber, 1945; Munro, 1945; Poppen, 1945; etc.). It is notoriously difficult to compare one surgeon's results with those of another in the same field, or the results of different surgeons operating on different parts of the body, but many surgeons have now reported operating on disk lesions with varying success and with failures in approximately 5 to 15 per cent of their cases. However, it would seem that the results of operation often fall short of this, for Marble and Bishop (1945) record that in the experience of one of the largest insurance companies in the United States dealing with compensation cases, less than 50 per cent of patients have had a favourable result, while Aitken and Bradford (1947) report that another insurance company has observed a 3 per cent mortality rate and only 55 per cent of successful cases. Shinners and Hamby (1944), however, state that 75 per cent of their compensation patients were removed after operation from the compensation rolls.

We have endeavoured to compare the results of surgery in intervertebral disk lesions with the results of operative procedures in internal derangements of the knee-joint, the worth of which is widely accepted. We selected internal derangement of the knee-joint for this comparison, because this condition, like disk protrusion, is a mechanical disturbance, which is non-lethal, which can cause prolonged and crippling disability, and which if left untreated can provoke secondary derangements that may cause persistent symptoms even if the primary lesion is then removed. Moreover, both conditions are customarily treated in the first place by rest or immobilization, and are only submitted to operation when the disability is appreciable and when

conservative therapy fails. MacKenzie and MacFarlane (1943) have published figures for knee cartilage operations in suitable form, to which we have added our own figures for disk operations (*Table XI*). It will be seen that the results of surgery in the two conditions are strikingly similar.

Table XI.—Results of Surgery in Disk Protrusion compared with Results of Surgery in Internal Derangement of the Knee-joint Statistics for which were compiled by MacKenzie and MacFarlane (1943)

Source	Percentage Results			Number of Cases
	Good	Fair	Poor	
Intervertebral disk protrusion :—				
Sciatica (our series)	72	23	5	75
Low-back pain (our series)	65	26	9	23
Internal derangement of knee :—				
Cantlie (R.A.M.C.)	63	25	12	83
Henderson (civilian)	77	14	9	298
Malkin (service)	64	26	10	86
Steindler (civilian)	77	15	8	86
Mackenzie and MacFarlane (R.C.A.M.C.)	71	22	7	303

With any operative procedure, even one in which a merely mechanical derangement is corrected, as in both the conditions compared above, there will inevitably be a proportion of failures and of partial successes. Potent causes of such failures, apart from mistaken diagnoses, are other associated mechanical derangements which may or may not be secondary to the primary lesion. With ruptured or dislocated cartilages of the knee-joint, these associated derangements may include osteochondritis of the articular surfaces, loose bodies, hypertrophy of the infrapatellar pad of fat, etc. With lumbar intervertebral disk lesions, the associated derangements include osteoarthritic and ligamentary changes in the corresponding interarticular and intervertebral joints, but, more important still, degenerative changes in other intervertebral disks. Disk protrusion is not a process confined to only one disk, the remaining disks being normal. Schmorl and his associates long ago showed that degenerative processes consequent upon ageing, as well as upon continued stresses and strains, will affect most, if not all, of the intervertebral disks of the spinal column, and there is a growing body of opinion that disk prolapses only develop in disks which are already degenerate (Hyndman, 1946; Begg, 1947; etc.). The persistence of back symptoms after disk operations is probably in large part accounted for by these degenerative changes in other intervertebral disks. For this reason complete cure is not possible in all cases.

CONCLUSIONS

Although complete cure cannot be obtained in all cases, the results of surgery are in a large measure conditioned by factors within the control of the surgeon. In this paper we have endeavoured to discuss these factors, and we may conclude by summarizing the more important of them as follows :—

1. A careful selection of cases is the first essential. All patients suffering from severe sciatica and/or low-back pain should be treated in the first instance by bed-rest or immobilization for at least one month. Those cases of sciatica which are not relieved appreciably by bed-rest should then be carefully investigated. A few will prove to have lesions like cauda equina tumour, or granulomatous or neoplastic disease of the spine, but most will be found suffering from disk lesions and should be submitted to operation. Before operating on patients with severe and intractable low-back pain, we in the present state of our knowledge would also add the criteria of definite physical signs and a positive myelogram as the basis of selection.

2. At operation the affected intervertebral disk must be exposed adequately. If this should prove difficult to achieve by an interlaminar approach, a laminectomy should be performed, for a poor exposure prevents the surgeon from curetting thoroughly the interior of the disk. Provided the interarticular joints are left intact, a laminectomy does not permanently weaken the spine or prolong convalescence.

3. The appearance of the pathological disk responsible for symptoms varies from case to case. Disk prolapses may be divided according to their macroscopic appearances into four groups—'projections', 'extrusions', 'intermittent prolapses', and 'scarred disks'. In particular, 'intermittent prolapses' are a group which are apt to be overlooked at operation, and it is probable that many of the negative explorations undertaken in the past occurred in cases with this type of lesion.

4. In order to avoid persistence or recurrence of symptoms, it is essential at operation to remove all loose and readily detachable tissue from within the interior of the pathological disk. In many instances this necessitates exposure and curettage of the pathological disk from both sides of the theca.

5. During convalescence the patient should undergo graduated exercises and physical training designed to strengthen weakened erector spinæ muscles and to promote general physical fitness. This hastens and facilitates the return to work.

6. Spinal fusion is seldom warranted.

7. If, after operation for disk prolapse, symptoms persist or after an interval recur, the question of re-exploration should be considered. In our experience continued symptoms have often been due to an inadequate removal of the diseased disk.

8. The surgeon must also be conversant with the common complications of disk operations and with the recognition and treatment of the various other disease conditions which may be encountered at operation simulating disk protrusion.

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THE SURGICAL TREATMENT OF CARCINOMA OF THE HYPOPHARYNX AND THE ŒSOPHAGUS*

BY HAROLD WOOKEY, TORONTO

A DISCUSSION of the surgical treatment of carcinoma of the œsophagus must necessarily include lesions involving the pharynx, or at least a portion of the pharynx. There is no essential difference in these two structures and, generally speaking, most malignant lesions of the pharynx and of the œsophagus are of the same type—epidermoid carcinomata.

Some of the tumours in the pharynx, however, are structurally different, and to these the terms of transitional-cell carcinoma and lympho-epithelioma have been applied. These tumours are highly anaplastic and do not form cell-nests or become keratinized. They are very malignant and are generally regarded as being radio-sensitive, whereas the epidermoid carcinomata grow more slowly and are definitely radio-resistant. The so-called transitional-cell carcinoma is commonly found in the nasopharynx and rarely in the hypopharynx, and, in our experience, not at all in the œsophagus.

In this paper, only that part of the pharynx lying below the epiglottis (generally known as the hypopharynx) and the œsophagus are being considered, for I believe that lesions in the nasopharynx and oral pharynx are not amenable to surgical treatment and may respond favourably to radiation. For convenience of description, the subject will be divided into three parts: first, the lesions involving the hypopharynx and upper end of the œsophagus; second, those occurring in the middle of the œsophagus; and, third, those involving the lower end of the œsophagus.

Cancer of the œsophagus is much more common in men than in women, about 80 per cent of the cases occurring in males, whereas malignant growths in the lower part of the hypopharynx, known as the

* Hunterian Lecture delivered at the Royal College of Surgeons of England on Sept. 30, 1947.

retrocricoid area, are almost entirely confined to women. The age in which the disease occurs is much the same as in cancer elsewhere—that is, in individuals over forty.

An early diagnosis is exceptional, for the distinctive symptom of dysphagia is often late in appearing and in the hypopharyngeal cases may be entirely absent. It is noticeable in case histories that a patient may experience some difficulty in swallowing at one period and then this symptom may disappear for a time, to return later with increasing severity. The first difficulty is usually in eating solid food, although fluids may be taken easily. Lesions beginning in the hypopharynx may be relatively small and difficult to see, the patient noticing only some discomfort on swallowing. In some instances, the first evidence of the disease is the appearance of a swelling in the neck due to the enlargement of lymph-nodes. Hoarseness or slight discomfort on swallowing referred to the neck should be regarded with suspicion and calls for careful examination of the larynx and pharynx.

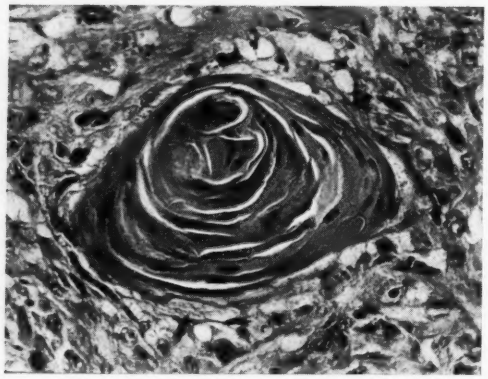


FIG. 261.—A microphotograph of a keratinizing carcinoma of the œsophagus. (× 200.)

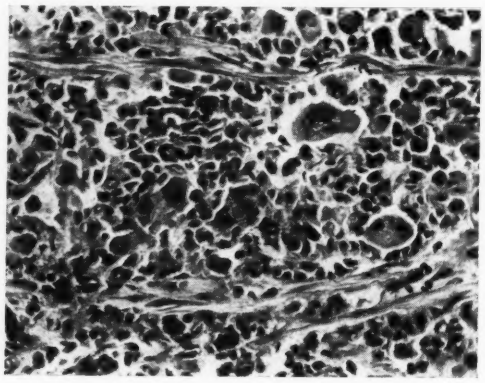


FIG. 262.—A microphotograph of an anaplastic carcinoma of the œsophagus. (× 150.)

Many patients, when admitted to hospital for treatment, are emaciated and generally in very poor condition. The following symptoms are grave in their significance: hoarseness, due to paralysis of a vocal cord; persistent pain in the chest or back; and cough. Paralysis of a vocal cord in mid-œsophageal lesions means that the disease has extended to the regional lymph-nodes in the superior mediastinum and has involved the recurrent laryngeal nerve. Pain in the back and persistent cough suggest that the growth has penetrated the œsophagus and has involved the lung, bronchus, or mediastinum by direct spread.

In the Toronto General Hospital it has been found that about 4 per cent of all cases of cancer occur in the hypopharynx or œsophagus. Of these, 25 per cent involve the hypopharynx or upper end of the œsophagus, 45 per cent the middle portion, and 30 per cent the lower end. A careful study of 70 autopsies of patients dying of cancer of the hypopharynx or œsophagus revealed the following facts: In 22 per cent of all cases there were no metastases, in 16 per cent regional lymph-nodes were involved, in 38 per cent there had been an extension into adjacent structures, and in 24 per cent there were widespread metastases. In lesions involving the hypopharynx and upper œsophagus widespread metastases were not found, but were most commonly present when the lower third of the œsophagus was involved.

Most of the tumours were epidermoid in type. There were two cases of adenocarcinoma and one of basal-cell carcinoma. From a histological point of view, the tumours were divided into those which showed a tendency to keratinization (*Fig.* 261), and those in which the tumour was anaplastic in type (*Fig.* 262). In this series of autopsies they were about equally divided. In the cases of keratinizing carcinoma there were no metastases in 39 per cent, whereas in the anaplastic group only 8 per cent failed to show metastatic spread. It would seem, therefore, that in the more highly differentiated forms of carcinoma the prognosis is definitely more favourable. These figures are based on autopsy studies and can fairly, then, be regarded as presenting the most pessimistic view possible. Hence, one might reasonably infer that where an early diagnosis is made, there is a very good chance that the disease is purely a local problem.

A patient who complains of discomfort in swallowing should be subjected to a very careful, complete examination of the pharynx and œsophagus. Information gained by X-ray studies during the swallowing of barium is of great value, but may not reveal a lesion in the hypopharynx. Consequently all parties should be subjected to an œsophagoscopic examination. Such an examination should be done very carefully and gently because of the danger of perforating or tearing the œsophagus. In removing a piece of tumour for biopsy, the section should be taken deliberately from the margin of the growth and not by biting blindly into the wall of the œsophagus. Unnecessary trauma may lead to mediastinitis which, though not necessarily fatal, will complicate subsequent operative procedures and, indeed, may make them impossible. X-ray films of the chest should be taken to exclude lesions of the lungs.

Surgical operations devised for the removal of malignant growths in the hypopharynx or in the œsophagus should include methods of reconstruction. The fate of the individual who is left with an

œsophageal fistula in the neck and a gastrostomy in the abdomen is a most unhappy one. In this paper, methods for the removal of malignant lesions in various positions are described, together with methods of reconstruction. Palliative procedures are not discussed.

THE TREATMENT OF LESIONS OF THE HYPOPHARYNX AND UPPER ŒSOPHAGUS

It is convenient to divide the cases in this group into three categories :—

1. Lesions occurring in the pyriform fossa or anterior wall of the pharynx, involving the back of the larynx. These cases are really extrinsic carcinomata of the larynx, and if surgery is to be undertaken it means the sacrifice of the larynx. This is often regarded as a very mutilating type of operation. However, providing the pharynx can be reconstructed so that the patient can take food normally, the loss of the larynx is of minor importance in a life-saving undertaking. *Fig.* 263 illustrates the objective of this operation.

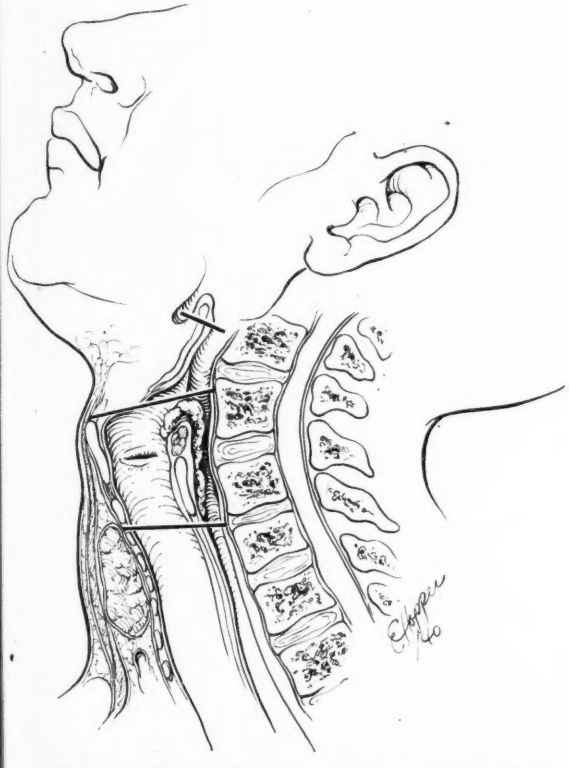


FIG. 263.—Diagram illustrating extensive carcinoma of the hypopharynx involving the larynx. The larynx and the hypopharynx are removed *en bloc*, as described in the text.

The patient is prepared for operation and the usual inhalation anæsthetic is given. A large flap of skin is reflected from the neck, as illustrated in *Fig.* 264. This flap is based either on the right or left side, depending upon the site of the lesion, and should have a wide base. The flap should include the subcutaneous fat and platysma muscle. After the reflection of this flap, the lower half of the sternomastoid muscle should be removed but the upper half preserved because of the important blood-supply carried through this muscle to the skin. This flap of skin is covered by a large pad saturated with saline. The carotid sheath is carefully preserved on each side. The isthmus of the thyroid is isolated and divided, being entirely separated from the trachea (*Fig.* 264). The lobe of the thyroid on the side of operation is removed. The trachea is divided immediately below the cricoid cartilage; it is separated from the œsophagus behind; and, into the distal end of the trachea is passed a rubber tube surrounded by an expanding bag. This expanding bag is inflated and through the tube anæsthesia is continued by means of suitable equipment. The larynx and pharynx are then carefully separated from the prevertebral fascia as high as the hyoid bone. A transverse opening is made into the pharynx just below the epiglottis and a direct view of the interior of the pharynx obtained. One can then estimate the correct level for dividing the pharynx above (*Fig.* 265). The œsophagus is isolated behind the trachea and as much of it as possible preserved. The œsophagus is now divided and the entire block of tissue, consisting of pharynx and larynx, is removed.

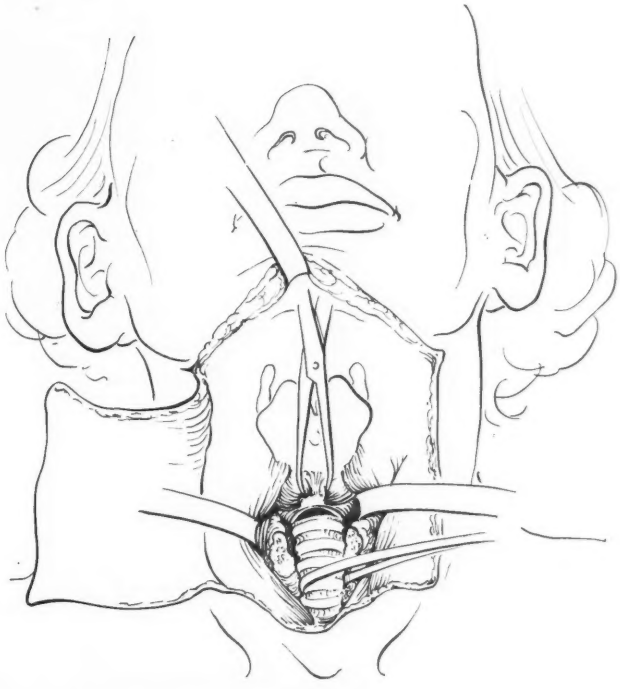


FIG. 264.—Diagram showing large skin-flap reflected, isthmus of thyroid divided, trachea exposed, and the position in which it is divided.

After having ligated all bleeding points, the reconstructive phase of the operation begins. The flap of skin is brought across the middle line so as to lie on the prevertebral fascia and it is secured to the prevertebral fascia by two longitudinally arranged lines of interrupted fine catgut sutures (*Fig.* 266). The upper border of the skin-flap is now sutured to the margin of the upper pharynx (*Fig.* 266). Here, interrupted fine chromic catgut sutures are used and are placed close together with

the knots tied so as to be superficial to the skin-flap. Having reached the margin of the pharynx, the line of suture is continued anteriorly. In a similar way, the cut end of the œsophagus is sutured to the lower margin of the skin-flap. A small elliptical part of the margin of the skin-flap below is removed so as to increase the surface of skin sutured to the œsophagus. After the completion of this manœuvre, the remainder of the skin-flap is used to cover, as far as possible, the rest of the wound and is secured in position by a few sutures (*Fig.* 267).

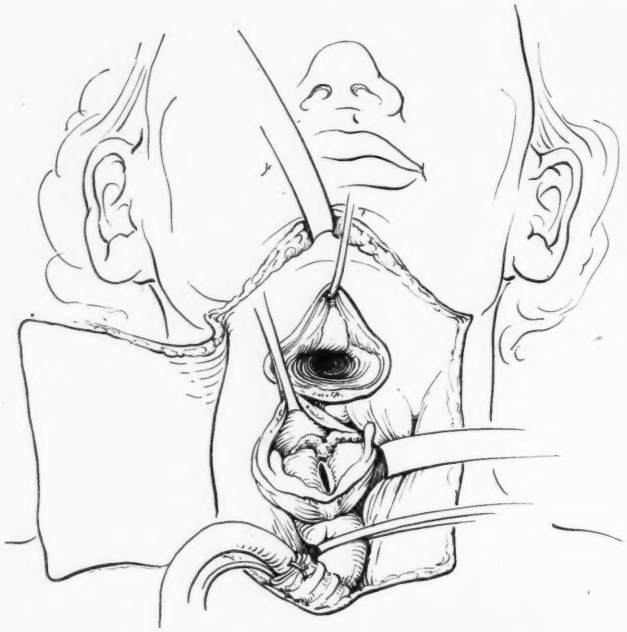


FIG. 265.—Diagram showing intratracheal tube in position, pharynx divided below hyoid, œsophagus mobilized ready for division.

FIG. 266.—Diagram illustrating method of using skin-flap for reconstruction of pharynx, sutures being placed above, and œsophagus ready for suture to lower margin of skin-flap.

FIG. 267.—Diagram showing first stage of reconstruction completed, line of œsophagus sutured below, upper suture line to pharynx now concealed, remainder of skin-flap being used to close raw surface as far as possible before Thiersh grafts are applied.

A duodenal tube is then passed down the œsophagus into the stomach and its upper end brought out through the nose. This tube now lies on the skin-flap and indicates the line of the reconstructed pharynx. There is a residual raw surface which now remains to be covered. This can be decreased in size by suturing the skin to the deep fascia of the neck. The remaining raw surface is then covered with a skin-graft taken from the thigh. This graft is secured in position by fine plastisute sutures. The upper end of the trachea is sutured to the skin above the sternum and it is well to do this in such a manner that the trachea projects about $\frac{1}{4}$ in. above the surface, as not uncommonly the upper ring of

A B

FIG. 268.—A, Posterior view of specimen, showing position of growth. B, View of specimen from above, showing involvement of the superior aperture of the larynx.

the trachea subsequently sloughs. A large tracheotomy tube is introduced into the trachea and the patient returned to bed, preferably in an oxygen tent. A blood transfusion is given throughout the

FIG. 269.—Photograph of patient, wounds having healed, fissure in the neck ready for closure.

operation if necessary and continued afterwards, together with intravenous saline and glucose. *Fig.* 268 shows an actual specimen viewed from behind and from above.

Following operation, careful nursing is necessary to keep the airway free of mucus. After about three or four days the patient can be fed through the duodenal tube. About five weeks should be

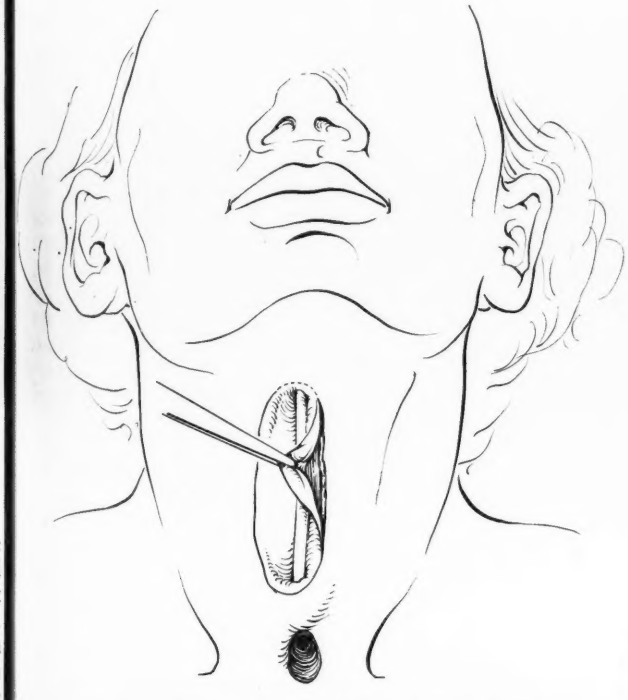


FIG. 270.—Diagram showing method of closing lateral fissure by incising and undercutting the skin.

allowed for the establishment of collateral circulation, after which the longitudinal sulcus in the neck (*Fig.* 269) is closed, as shown in *Figs.* 270, 271. In this way an adequate tube of skin has replaced the pharynx

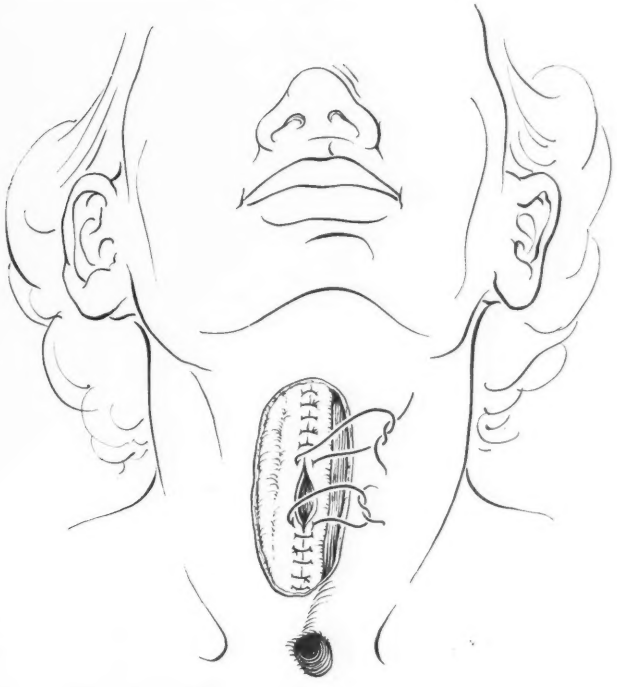


FIG. 271.—Diagram showing margins of skin-tube being sutured.

and is now completely buried. When the wound has completely healed, usually not before three

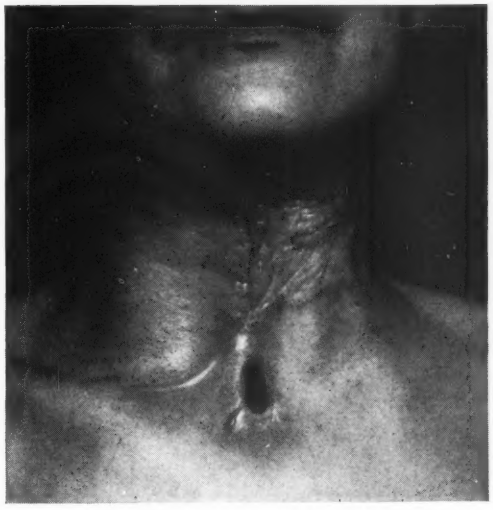


FIG. 272.—Photograph of patient after completion of reconstruction, taking food normally and ready to leave the hospital.

weeks, the duodenal tube is removed and the patient allowed to take fluids and, later, other types of food (*Fig.* 272).

2. In the second type of case, in which the lesion is confined to the retrocricoid area (*Fig.* 273, upper

circle), and does not involve the larynx or its immediate surroundings, the operation is modified and the larynx is preserved. Anæsthesia is carried out by an intratracheal tube passed through the nose or the mouth, preferably through the nose. A similar flap of skin is fashioned as previously described. The lobe of the thyroid on the side of operation is mobilized, the superior and inferior thyroid vessels are severed and ligated, the thyroid lobe is pulled over, and by this means the pharynx and larynx are rotated towards the opposite side. One then approaches the pharynx on the inner side of the carotid sheath, which is carefully preserved. The anterior belly of the omohyoid muscle is removed. The œsophagus is mobilized behind the trachea and up to the lower margin of the cricoid cartilage. An opening is made in the lower part of the pyriform fossa and the interior of the hypopharynx is visualized. The pharynx is carefully separated from the larynx and divided at a suitable level and completely freed, together with the tumour, from the cricoid cartilage. The œsophagus is divided below, after which the reconstruction is begun.

The flap of skin which has been previously prepared is brought across the midline so as to lie on the prevertebral fascia well over beyond the midline and is secured to the prevertebral fascia by a series of interrupted catgut sutures (*Fig.* 274). There should be no tension of this skin-flap, the cut edges of which are carefully sutured to the margin of the pharynx above and to the œsophagus below (*Fig.* 274). The lobe of the thyroid gland, which has been freed, is now removed and the remainder of the skin-flap is laid across the front of the larynx and trachea as far over to the opposite side as possible. This is now sutured in place and the raw surface made smaller, after which it is covered with a Thiersch graft. A duodenal tube is passed down the œsophagus and the upper end brought out through the nose. It is advisable to do a tracheotomy at the end of this operation, for post-operative œdema of the larynx may require an emergency tracheotomy. I consider that a tracheotomy is best done at the time of operation. The tube may be removed in a few days after œdema has subsided.

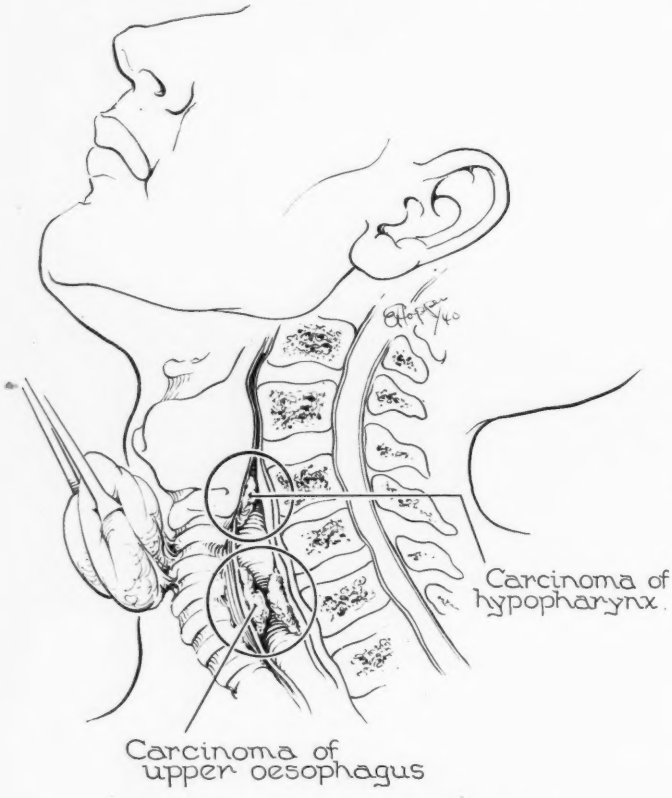


FIG. 273.—Diagram illustrating a retrocricoid carcinoma of the pharynx (top circle) and a carcinoma of the upper end of the œsophagus (lower circle). Both types described in the text.

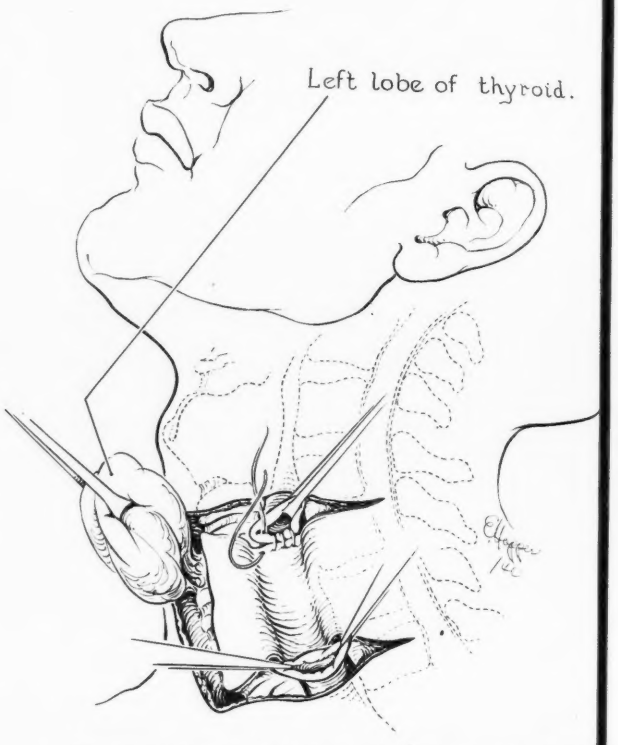


FIG. 274.—Diagram illustrating method of reconstruction of lower pharynx and upper œsophagus in cases of retrocricoid and upper œsophageal carcinomata. The larynx has been preserved. Lobe of thyroid retracted.

After five or six weeks this deep lateral fissure in the neck is closed, leaving a buried tube of skin which replaces that part of the pharynx and œsophagus which has been removed. The method of closing this fissure has already been discussed.

Fig. 275 is an X-ray print showing a filling defect in the retrocricoid area produced by a polypoid carcinoma. *Fig.* 276 is a photograph of the patient in whom this tumour (*Fig.* 277) has been removed. The fissure in the neck is about to be closed. *Fig.* 278 shows the patient with the duodenal tube ready for removal. *Fig.* 279 shows the scars in the neck on completion of a similar operation.

3. In the third type of case one is dealing with a true cancer of the upper end of the œsophagus. The same type of operation is possible, provided the growth is high enough in the œsophagus to

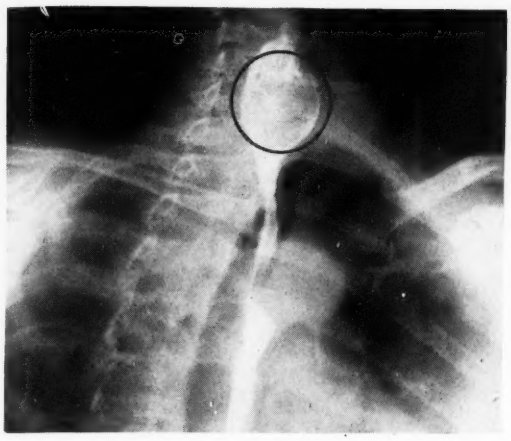


FIG. 275.—X-ray film on swallowing barium, showing a filling defect due to a retrocricoid growth.

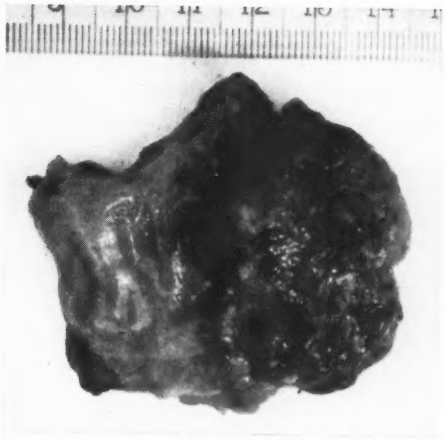


FIG. 277.—Photograph of specimen of retrocricoid growth which has been removed.

FIG. 276.—Photograph of patient in whom a retrocricoid growth has been removed, ready for closure of lateral fissure.

FIG. 278.—Photograph of patient on completion of operation for removal of retrocricoid growth. Duodenal tube ready for removal.

FIG. 279.—Photographs of patient in whom a retrocricoid growth has been removed, about to leave the hospital and taking food normally.

be reached through the neck. The length of œsophagus which can be exposed through the cervical approach varies in different individuals, but, as a rule, one has command of about 4 in. As œsophageal growths, especially when seen reasonably early, do not extend very widely at the periphery, a margin of 1½ in. below the tumour is sufficient when dividing the œsophagus.

In *Fig.* 273 the site of an upper œsophageal lesion is illustrated by the lower circle. *Fig.* 280 shows a filling defect in the upper end of the œsophagus. A photograph of a patient (*Fig.* 281) shows the fissure in the neck ready for closure. The tumour removed is shown in *Fig.* 282, and in *Fig.* 283 the patient is shown just before leaving hospital.

The methods of reconstruction are essentially the same as previously described. The subsequent closure of the fissure in the neck is done when collateral circulation has been established. In male subjects the growth of hair in the neck has been a complication, as illustrated in *Fig.* 284. The hair is destroyed by radiation before the fissure is closed.

Although one has been agreeably surprised to find that strictures have not occurred at the suture line between skin and œsophagus, before closing the lateral fissure in the neck one should make certain that this has not occurred. These skin-tubes will function satisfactorily and some cases which have been followed for several years are able to take all types of food. Operation on lesions of the hypopharynx and upper œsophagus should not be undertaken in advanced cases or where there are metastatic

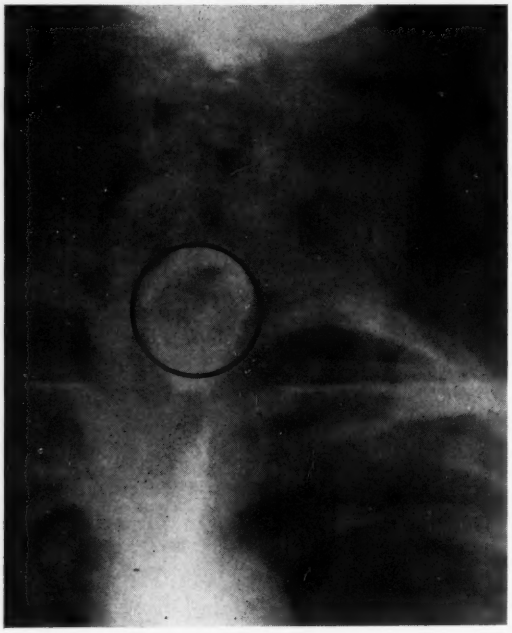


FIG. 280.—Radiograph on swallowing barium, showing a filling defect of a carcinoma of the upper end of the œsophagus.

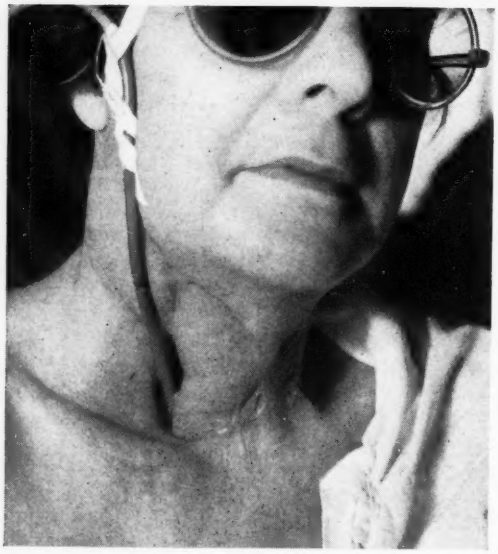


FIG. 281.—Photograph of patient after the excision of a lesion at the upper end of the œsophagus, ready for closure of the lateral fissure.

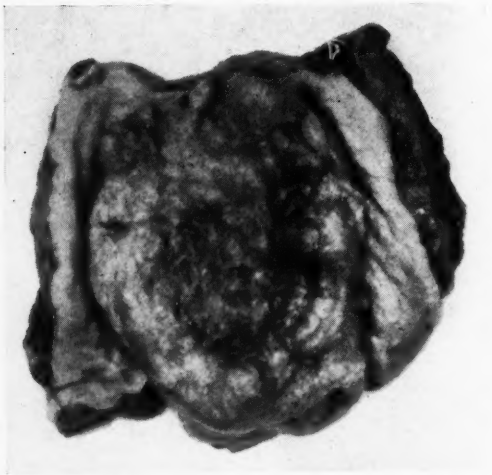


FIG. 282.—Photograph of lesion in upper œsophagus.

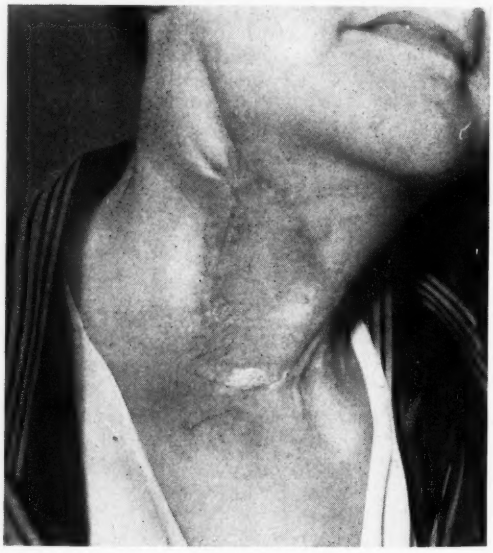


FIG. 283.—Photograph of patient after closure of fissure, ready for discharge from the hospital.

nodes. If this rule is not followed, one will be disappointed to find early recurrences, usually in the nodes of the neck or in the mediastinum.

Lesions involving the upper end of the œsophagus too low to be reached through the neck must be dealt with in some other manner, as will be described later in the text.

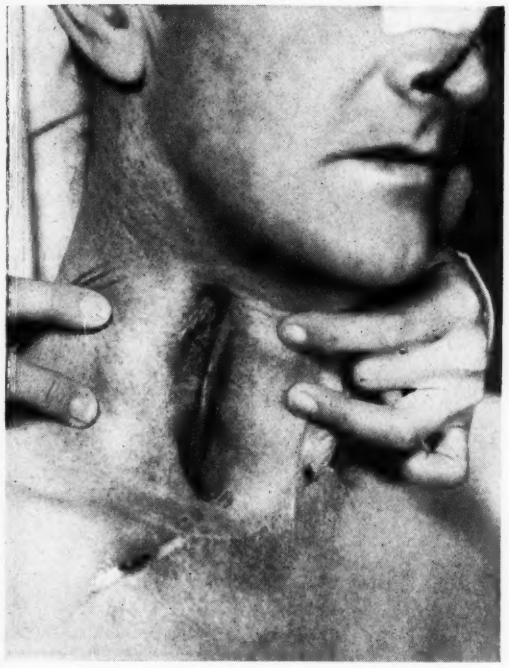


FIG. 284.—Photograph of a male patient in whom a lesion of the upper œsophagus has been removed, illustrating the complication of hair growing in skin-tube, as described in the text.

THE TREATMENT OF LESIONS OF THE MID-ŒSOPHAGUS

The surgery of cancer of the œsophagus is still in a state of evolution. Following Torek's original work, operations for removal of the œsophagus have been done by surgeons throughout the world. The ability to take food in a normal way is of vital importance to the patient and many ingenious methods of œsophageal reconstruction have been described. However, it would seem that intrathoracic reconstruction, when possible, is the simplest solution, and operations for this purpose are now becoming standardized and fairly widely practised.

Cancer of the intrathoracic œsophagus varies somewhat in its exact location, but there are two main groups—those occurring just behind and below the arch of the aorta (the mid-œsophagus), and those affecting the lower end. Our autopsy studies have shown that in the intrathoracic growths, nodes are involved in a relatively high percentage of cases and, in more advanced lesions, direct extension of the growth has made them inoperable. Some idea of the feasibility of operation can be determined by X-ray pictures of the œsophagus on swallowing barium, by stereoscopic radiographs of the chest, and by the presence or absence of grave symptoms already discussed. It has also been found that in mid-œsophageal lesions, as well as in growths occurring at the lower end, lymph-nodes below the diaphragm may be involved. The paracardial lymph-nodes, those along the lesser curvature of the stomach, or those in relation to the pancreas may be involved.

For this reason I believe that a preliminary laparotomy is desirable, for though the local tumour

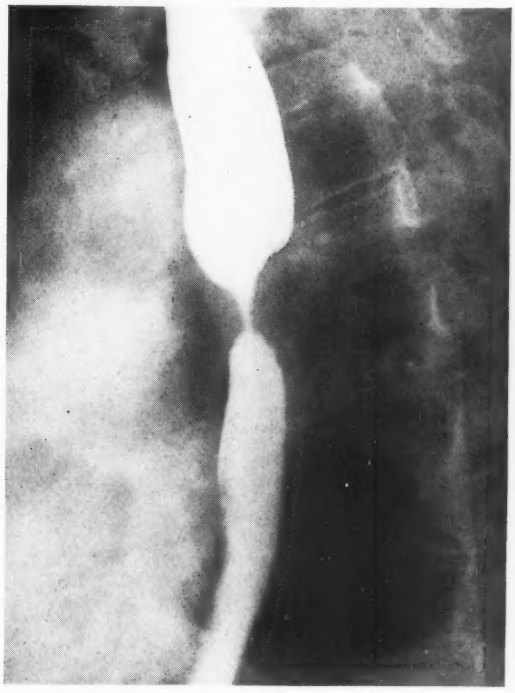


FIG. 285.—X-ray film on swallowing barium, showing a mid-œsophageal carcinoma. (Case described in the text.)

in the œsophagus may be removed successfully, the presence of intra-abdominal metastases would make an extensive operation unwise. A temporary jejunostomy may be done when one has determined that a radical operation is feasible. Patients who are in poor condition will be improved by a short course of jejunostomy feeding. If a successful transthoracic operation is done, post-operative jejunostomy feedings allow the stomach to be kept at rest and empty while healing of the anastomosis is taking place.

The jejunostomy is a simple one in which a catheter is introduced into the jejunum about 18 in. from its upper end and brought out through a small stab wound in the loin. One objection to this procedure has been the possibility of subsequent intestinal obstruction. On only one occasion have I met with this complication and it was successfully relieved.

After two weeks of preliminary jejunostomy feeding, in which the patient becomes accustomed to this method of taking food, the major operation is done through the left side of the chest. *Fig.* 285 is an X-ray print showing a typical mid-œsophageal lesion which was present in the case which is now described.

Under intratracheal anæsthesia the patient lies on the right side and an incision is made in the chest wall just below the inferior angle of the scapula (*Fig.* 286). A rib may be resected or the posterior

FIG. 286.—Diagram showing patient in position on table with incision through chest wall.

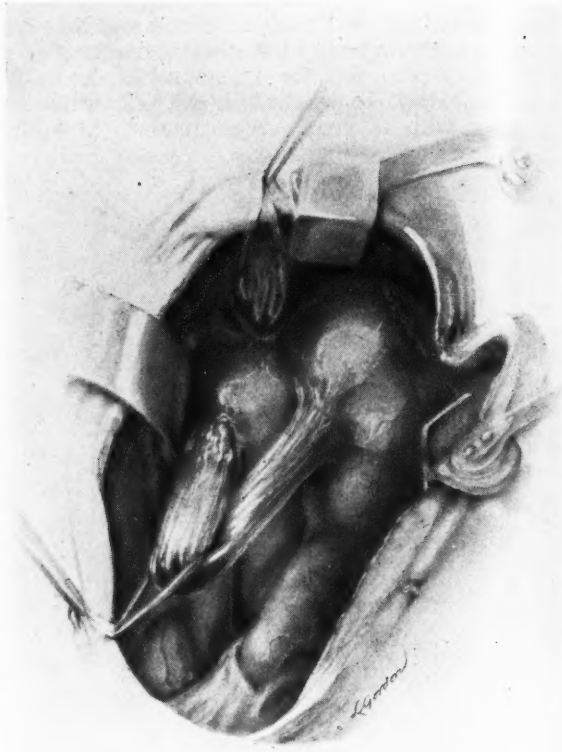


FIG. 288.—Illustration of stomach brought up through diaphragm and shown in position within chest.

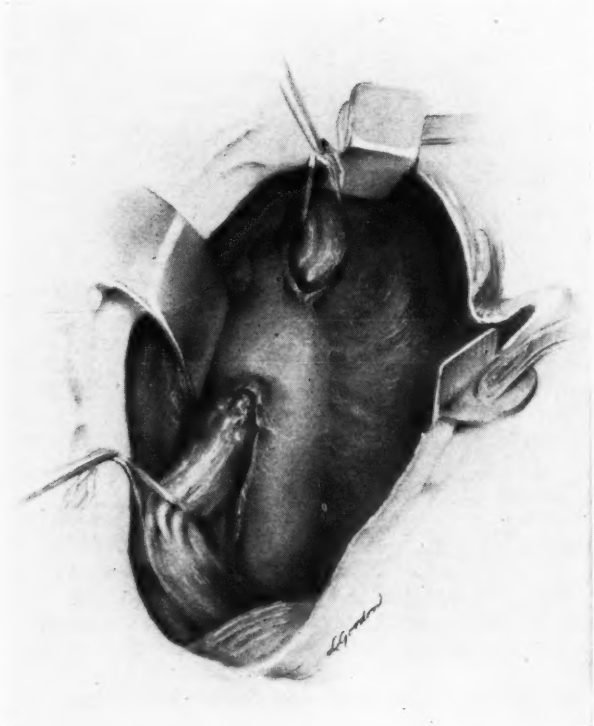


FIG. 287.—Illustration of mobilization of œsophagus above and below the arch of the aorta.

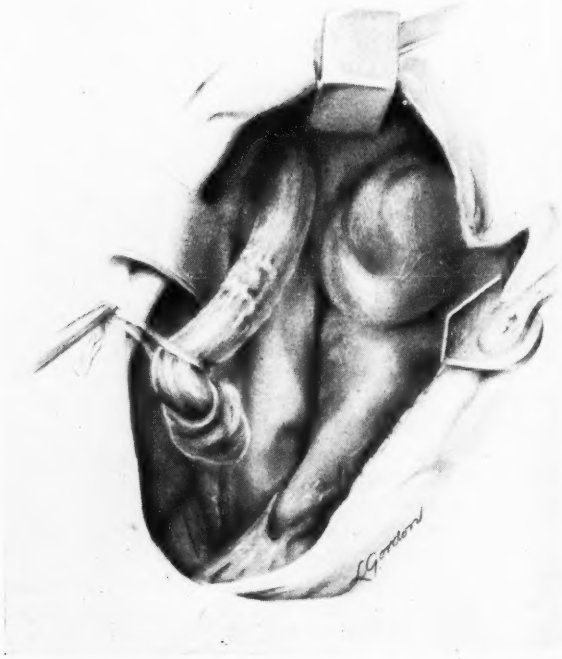


FIG. 289.—The œsophagus has been divided and its lower end invaginated into the stomach. The œsophagus has been pulled through above the arch of the aorta. The posterior wall of the stomach has been fixed to the chest wall above.

ends of two ribs divided. The pleura is opened and the ribs spread widely apart by means of a suitable chest retractor. At this point the anæsthetist is asked to inflate the collapsed lung, as one wants to be quite certain that it is possible to expand the lung at any time. The œsophagus is found at its lower end through an incision in the parietal pleura below the inferior pulmonary ligament and it is traced upwards until the tumour is encountered.

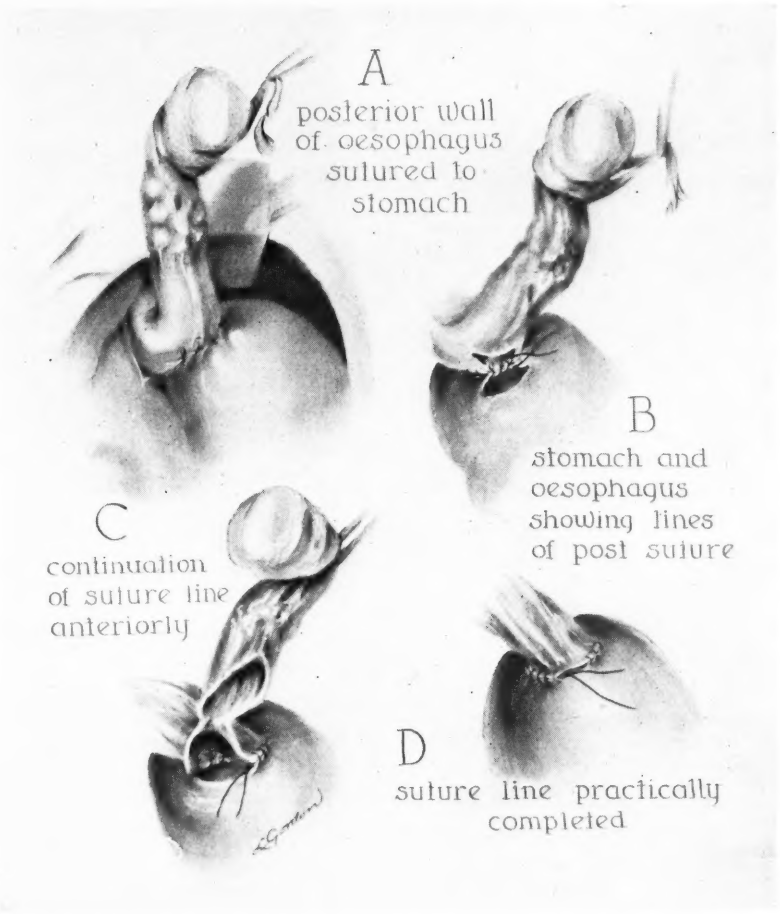


FIG. 290.—Diagrams showing method of anastomosis of œsophagus to an opening in the anterior wall of the stomach.

This is then freed by blunt dissection. One should remember that on the right side of the chest the vena azygos major is quite close to the œsophagus in this area and, if torn, might lead to uncontrollable hæmorrhage, as it is difficult to reach from the left side of the chest. Having found that the tumour may be freed from the surrounding structures, an opening is made in the parietal pleura above the arch of the aorta and the œsophagus is exposed at this level (*Fig.* 287).

The entire œsophagus, together with the tumour, when completely mobilized can be freely moved upwards and downwards. In the mobilization of the tumour the opposite pleura may be accidentally opened, but with positive-pressure anæsthesia this is not a serious complication. However, if the right pleura should have been torn, the opening is carefully closed. The diaphragm is now divided from the œsophageal opening up to the costal margin. All bleeding points are ligated. The stomach is mobilized along the greater and lesser curvatures and freed from the spleen. The upper branches of the left gastric artery are severed and ligated. It is important to preserve the lower branch if possible. The stomach is brought up into the chest so that the fundus reaches to a point above the arch of the aorta (*Fig.* 288).

Having decided that this is possible, the phrenic nerve as it lies on the side of the pericardium is crushed by means of an artery forceps, thus paralysing the right diaphragm. The lower end of the œsophagus is divided and inverted into the stomach. Its cut upper end is covered by means of rubber tissue so as to prevent contamination, and the entire œsophagus is then drawn upwards from its bed to a position entirely within the left thorax. The stomach is then brought up and anchored to the parietal pleura as high up as possible by a series of silk sutures (*Fig.* 289).

An anastomosis is then done between the upper end of the œsophagus, well above the tumuor and the stomach, the œsophagus being placed on the anterior wall and sutured to it by interrupted silk sutures, the junction being made with the stomach through a small incision in its anterior wall. This anastomosis

is done by silk sutures closely placed and interrupted (*Fig.* 290). The line of anastomosis is protected by bringing the stomach over it or around it in any manner that is feasible (*Fig.* 291). The diaphragm is then closed around the stomach, but not so tightly as to cut off the blood-supply coming from below. The chest is now closed with closed drainage, after having secured all bleeding points. At the end of the operation the lung is inflated and the patient returned to bed in an oxygen tent. Blood

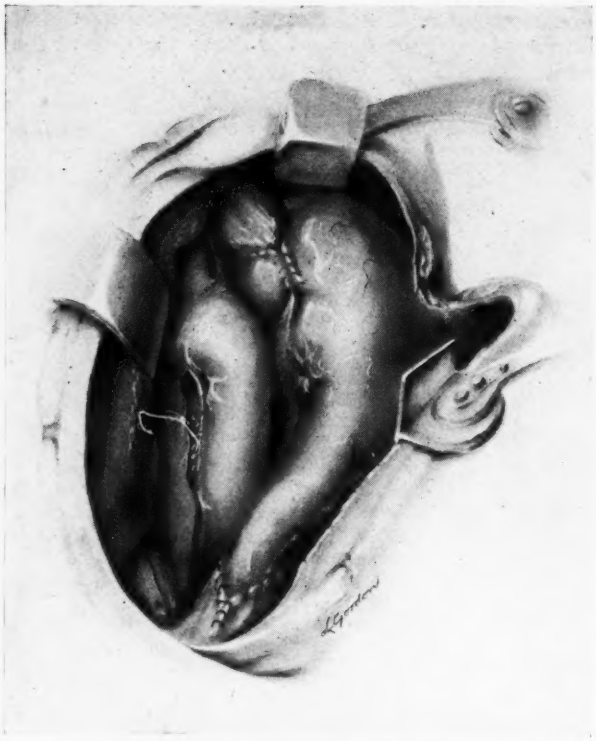


FIG. 291.—Illustration of completion of anastomosis with opening in diaphragm closed around the stomach.

FIG. 292.—X-ray film on swallowing barium, showing stomach in chest. Patient taking food normally, ready for discharge from hospital.

FIG. 293.—X-ray film of mid-œsophageal carcinoma. Second case described in text on mid-œsophageal carcinoma.

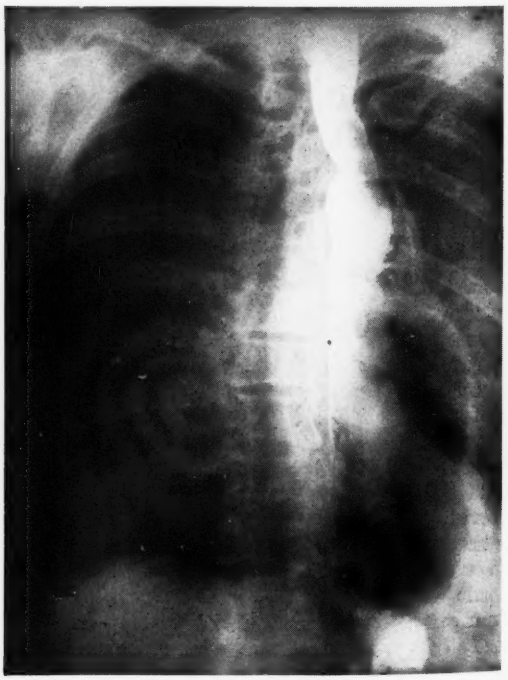


FIG. 294.—Same case. X-ray film on swallowing barium, showing stomach in chest, containing barium and gas. Patient taking food normally, ready for discharge from hospital.

transfusion is given throughout the operation and following operation, together with intravenous glucose and saline.

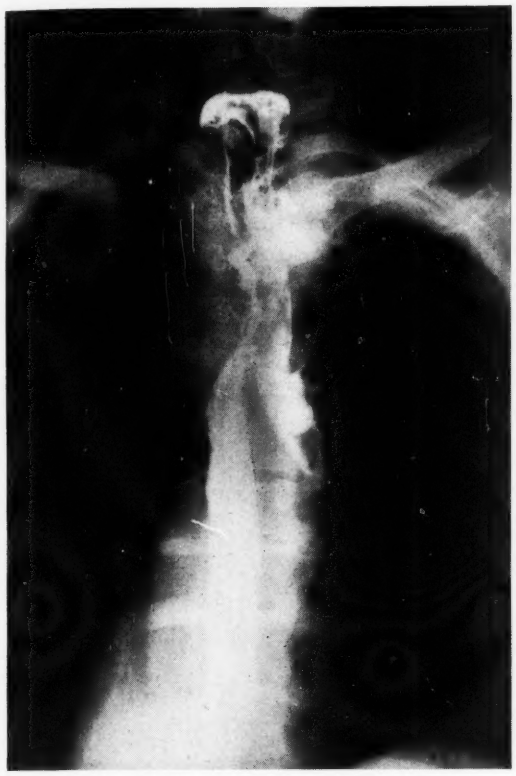


FIG. 295.—Radiograph on swallowing barium, showing an œsophago-tracheal fistula.

FIG. 296.—X-ray film showing an inoperable carcinoma of mid-œsophagus with extension into the lung.

Post-operative nursing is of the utmost importance. The patient should be constantly watched and be turned frequently. Jejunal feeding is commenced on about the third day. I believe that the jejunostomy now plays an important part, as it is not desirable to subject the suture line to any strain or to permit the stomach to become distended. A useful measure is to have passed a duodenal tube through the anastomosis into the stomach so that it can be kept empty. At the end of about the second week, the patient is allowed to take fluids by mouth, and, when these are tolerated, the jejunostomy tube is removed.

Fig. 292 is a print from an X-ray film on swallowing barium, showing the position of the stomach in the chest following the operation described above. The patient is able to take food normally.

Fig. 293 shows a lesion in the mid-œsophagus.

Fig. 294 is an X-ray print on swallowing barium, showing the stomach in the chest, outlined by gas as well as barium. This patient was discharged from hospital taking food normally.

Radiographs of the œsophagus may indicate inoperability in a striking manner. *Fig.* 295 represents an œsophago-tracheal fistula. *Fig.* 296 is a radiograph of an œsophageal carcinoma with direct spread to the lung.

THE TREATMENT OF LESIONS OF THE LOWER END OF THE ŒSOPHAGUS

Carcinoma of the lower end of the œsophagus may involve a part of the stomach. A great many cases prove to be inoperable because of the extensive involvement of lymph-nodes below the diaphragm and of adjacent structures.

In dealing with the problem, an excellent exposure may be obtained by means of an oblique incision across the upper left rectus muscle (*Fig.* 297, inset). The right rectus muscle is displaced laterally. The peritoneum is opened and the upper abdomen is explored. If the condition proves to be operable, the incision is produced across the rib cartilages and along the intercostal space. The diaphragm is divided from the costal margin to the œsophageal hiatus. It is not necessary to remove a rib or to sever any ribs posteriorly, for by means of a rib retractor a satisfactory exposure can be obtained. The ends of the costal cartilages are removed. This facilitates closure of the wound on completion of the operation.

The stomach is mobilized and the point at which it is to be divided is carefully chosen (*Fig.* 297). After division of the stomach the cut distal end is oversewn and inverted. The remainder of the stomach is brought up without tension into the chest and firmly anchored to the chest wall at a level above the line of proposed anastomosis. An anastomosis between the lower end of the œsophagus and the anterior wall of the stomach is carefully done, using interrupted fine silk sutures. The phrenic nerve is crushed, the diaphragm closed around the stomach, which partly, together with the anastomosis, now lies within the thorax (*Fig.* 298).

A jejunostomy is now quickly done and the wound in the chest and abdomen is closed. The chest is drained by closed drainage.

Fig. 299 is a radiograph of a lower œsophageal lesion which was operated upon in the manner described. *Fig.* 300 shows the outline of the œsophagus and stomach of the same patient taken just before leaving the hospital. The patient was able to take food normally.

SPECIAL PROBLEMS

In some cases of carcinoma of the œsophagus the procedures which have been described are not possible. In one type the lesion is situated at too low a level to be reached by a cervical approach,

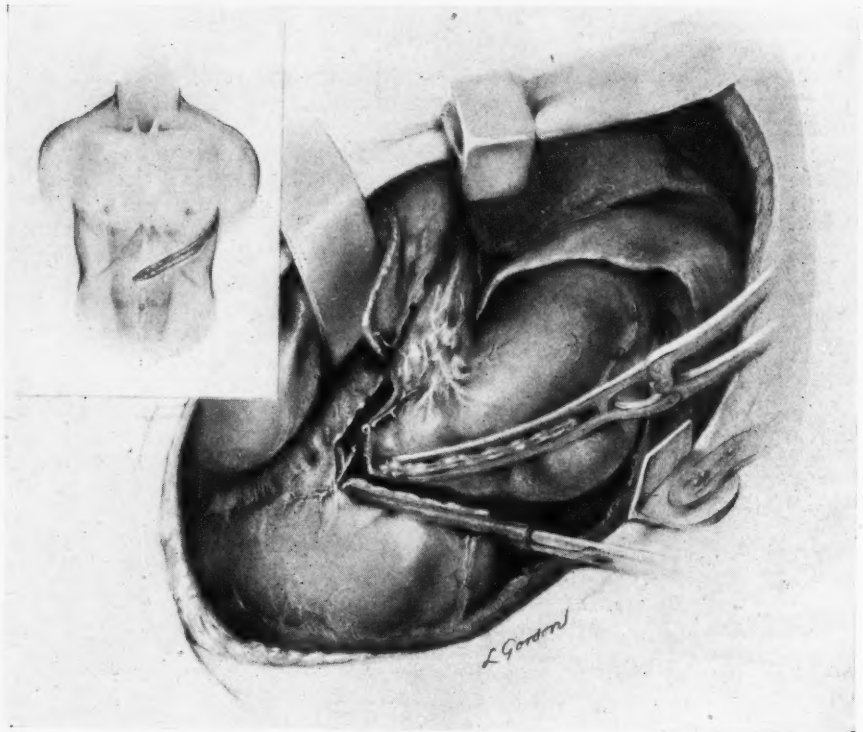
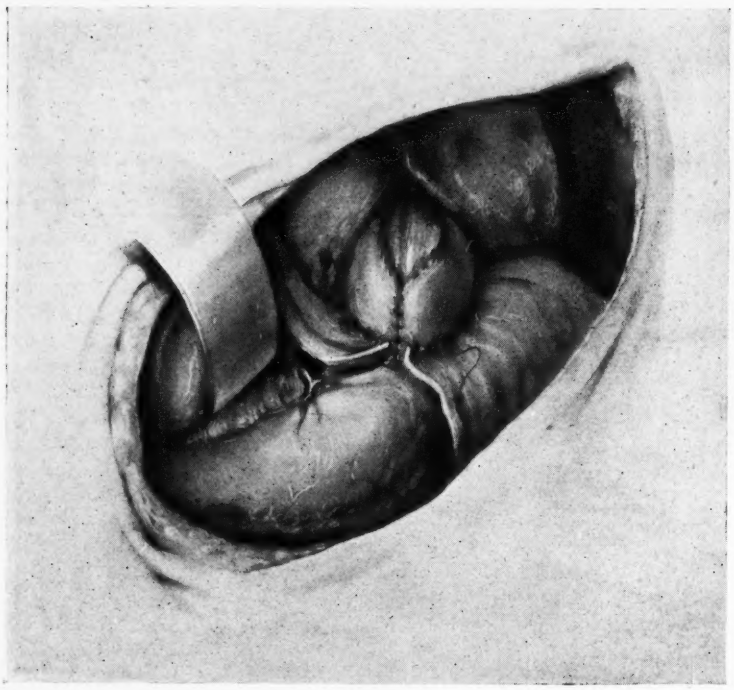


FIG. 297.—Drawing illustrating excision of lower œsophagus and part of stomach. Line of incision shown in inset. Portion of stomach mobilized and divided, showing tumour at lower end of œsophagus. The upper branches of the left gastric artery have been severed.



and, being above the arch of the aorta, does not permit an intrathoracic anastomosis with the stomach. Such a lesion is illustrated in the X-ray print, *Fig.* 301.

In another type of case (*Fig.* 302) there was an extensive involvement of the œsophagus and stomach. An anastomosis below the arch of the aorta was impossible and the pyloric portion of the stomach could not be brought to a level high enough in the chest to permit a safe anastomosis.

In such cases an œsophagectomy and jejunostomy should be done. The divided upper end of the œsophagus is brought out in the neck, and the lower

FIG. 298.—Drawing showing completed anastomosis between œsophagus and stomach. The opening in diaphragm being closed around stomach.

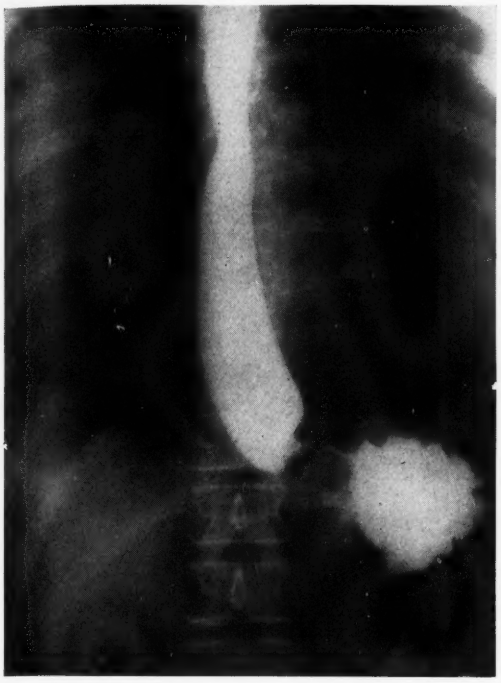


FIG. 299.—X-ray film showing filling defect of a lower œsophageal lesion. (Case described in text.)

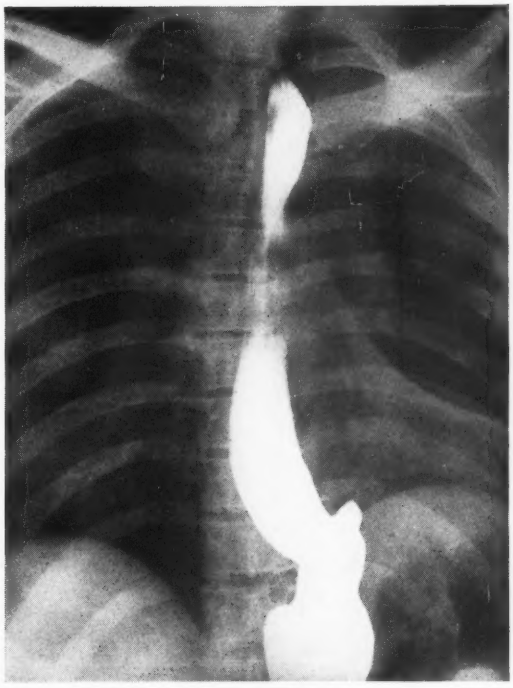


FIG. 300.—X-ray film on swallowing barium, showing anastomosis of œsophagus and stomach in lower part of chest.

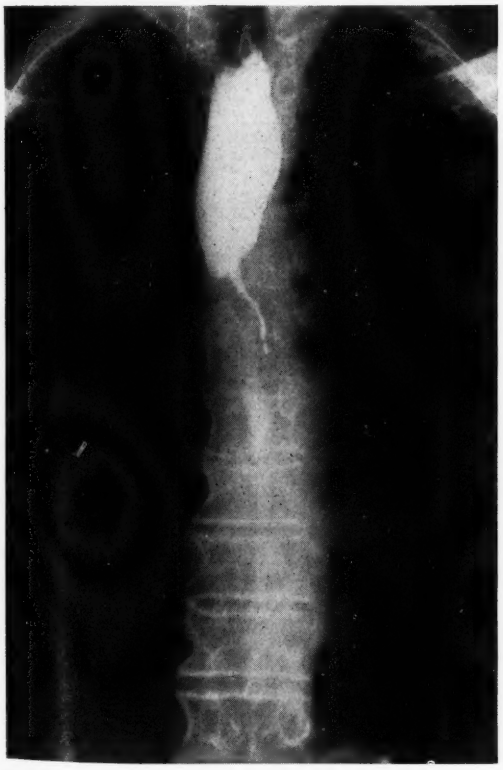


FIG. 301.—X-ray film on swallowing barium of a lesion in the œsophagus too high for an intrathoracic reconstruction.

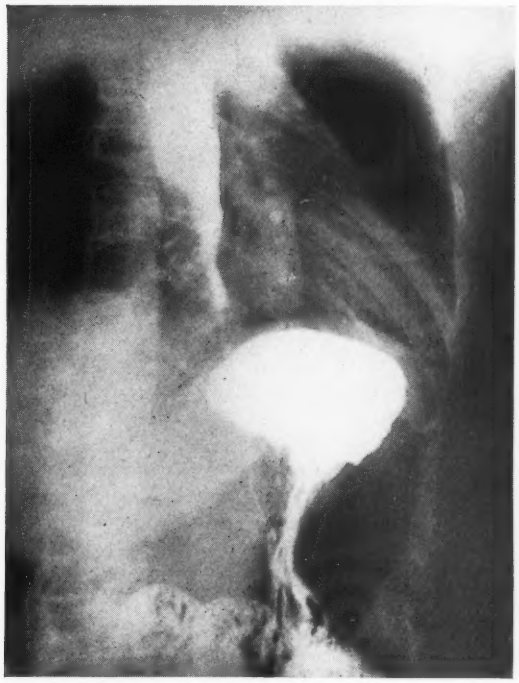


FIG. 302.—X-ray film showing extensive involvement of the lower end of the œsophagus in which it was necessary to remove a large part of the stomach and an intrathoracic reconstruction was not possible.

stump of the œsophagus, if it is not involved, is brought out through a small incision in the abdominal wall just below the xiphoid process. A jejunostomy is essential for feeding the patient until the reconstruction of the œsophagus can be undertaken, usually about three weeks after the primary operation.

I have found that a skin-tube in front of the sternum is a satisfactory method of reconstruction, particularly where it has been possible to preserve

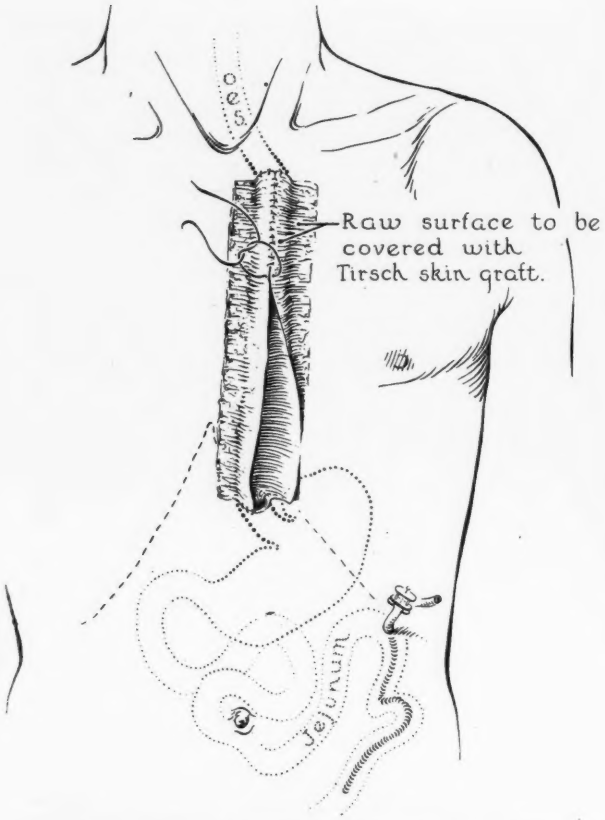


FIG. 303.—Diagram illustrating method of making new œsophagus from skin of chest wall; stump of lower end of œsophagus preserved.

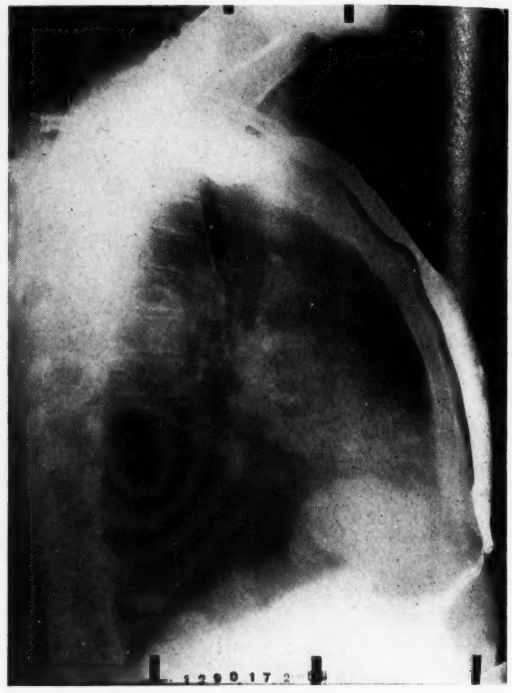


FIG. 304.—X-ray print on swallowing barium, showing the skin-tube in front of the sternum carrying barium down into the stomach.

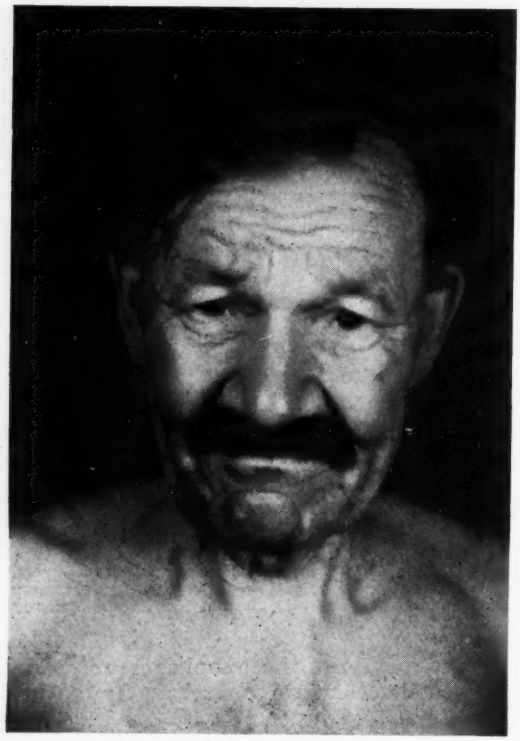


FIG. 305.—Photograph of patient, illustrated in *Figs.* 303, 304, taken 9 years after operation. Can take all types of food.

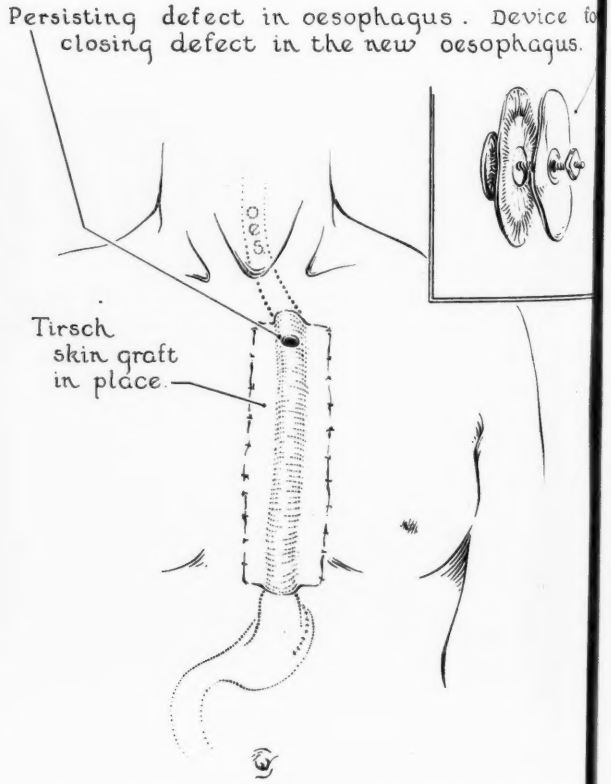


FIG. 306.—Diagram illustrating method of making new œsophagus from skin of chest wall, a large part of stomach having been removed. Inset of diaphragm for closing defect in new œsophagus. Method employed in case illustrated by *Figs.* 302, 307–311.

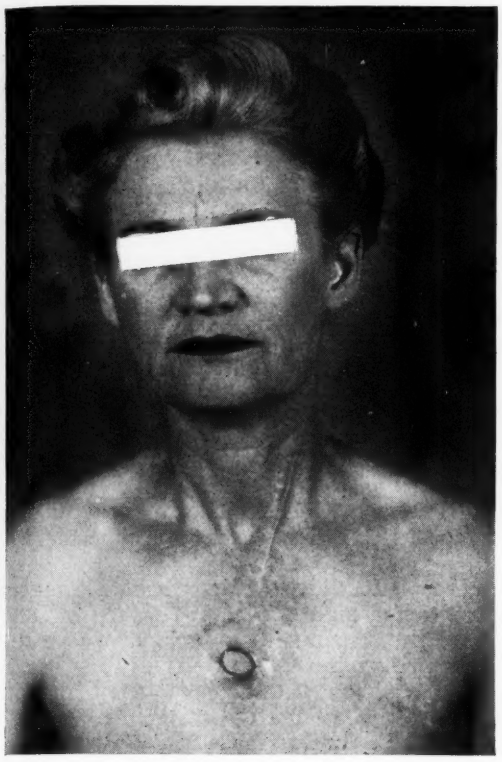


FIG. 307.—Photograph of patient showing defect in the anterior wall of skin-tube.

FIG. 308.—Photograph showing rubber diaphragm (inset, *Fig.* 306) closing defect in skin-tube.

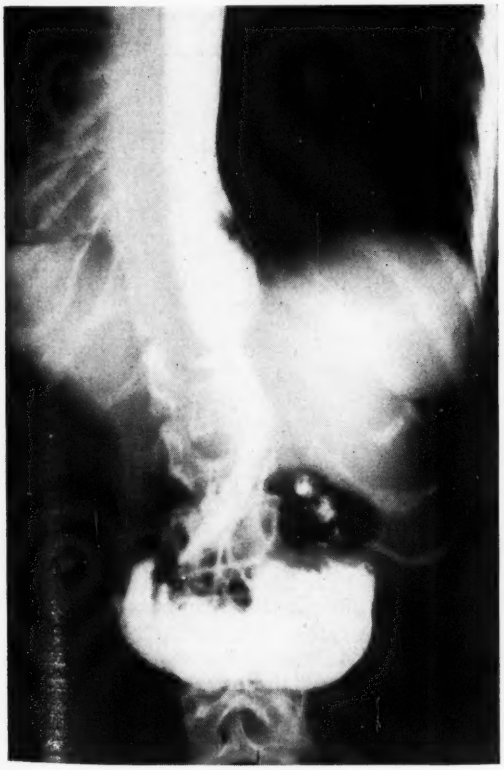


FIG. 309.—X-ray film showing barium in skin-tube and stomach, front view.

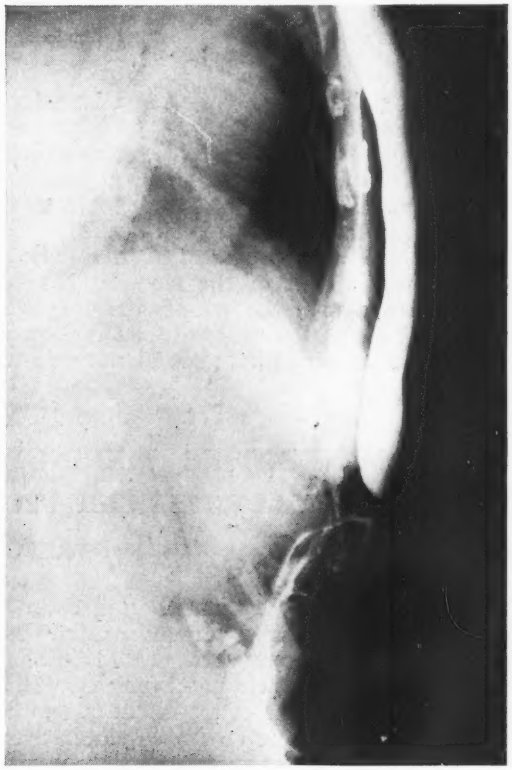


FIG. 310.—X-ray film showing barium in skin-tube, lateral view.

the lower inch of the œsophagus (*Fig.* 303). The skin-tube should be constructed slightly to the left of the midline so as to preserve the perforating branches of the internal mammary artery. A failure of healing by first intention in the skin-tube may result in a troublesome fistula which may require

FIG. 311.—Photograph of patient 5 years after operation. Can take all types of food.

a tube-graft for closure. *Fig.* 304 is a lateral view of the reconstructed œsophagus on swallowing barium, showing the connexion with the stomach. *Fig.* 305 is a photograph of this patient nine years after operation. He has always been able to take all types of food and is still in good health.

This method of reconstruction may also be employed where a part of the stomach has been removed together with the œsophagus (*Fig.* 306). In the case of the patient whose lesion is shown in *Fig.* 302, there remained a defect in the skin-tube which proved difficult to close. *Fig.* 307 is a photograph of the patient, showing this defect. It was closed by means of a rubber diaphragm, a drawing of which is shown in *Fig.* 306 (inset). *Fig.* 308 is a photograph of the patient with the diaphragm in place. *Fig.* 309 is a radiograph of this patient's œsophagus and stomach after swallowing barium, viewed from in front. *Fig.* 310 is a lateral view of the reconstructed œsophagus. *Fig.* 311 is a photograph of the patient as she is to-day, five years after operation. She takes food normally.

SUMMARY

The surgical treatment of various types of carcinoma of the hypopharynx and œsophagus has been described and methods of reconstruction of the œsophagus which have proved to be satisfactory. These extensive operations should be undertaken only in carefully selected cases in which a reasonably early diagnosis has been made, as otherwise early recurrence of the disease may be expected.

In the work which is described, the author is indebted to the pioneers in this branch of surgery, both in Great Britain and America, of whose experience and writings he has made the fullest use. He is also indebted to his colleagues in the University of Toronto; to the late Professor Clarence Starr and to Professor W. E. Gallie, Heads of the Department of Surgery, for their help and encouragement; to Professor Wm. Boyd, Department of Pathology, for the microphotographs and pathological data; to Professor J. C. Boileau Grant, Department of Anatomy, for anatomical suggestions; to Professor H. Shields and his staff, Department of Anæsthesia, for their operative assistance; to Miss Maria Wishart and Mrs. L. Gordon, Art Department of the University, for the many drawings. He is also indebted to Dr. G. E. Richards, Director of the Radiological Department of the Toronto General Hospital, for his kindness in supplying X-ray prints and photographs; to the nursing staff of the Toronto General Hospital for their valuable services in the post-operative care of these patients; and, finally, to the Editors of *Surgery, Gynecology and Obstetrics* for their permission to make use of drawings and photographs illustrating lesions of the pharynx and upper œsophagus, which had previously been published in that journal.

GRAM-NEGATIVE MENINGITIS FOLLOWING HEAD WOUNDS

WITH ESPECIAL REFERENCE TO INFECTION WITH COLIFORM BACILLI

BY WALPOLE LEWIN, OXFORD*

OF the various bacteria commonly found in war wounds, the Gram-positive organisms, clostridia, staphylococci, and streptococci claim the first attention by reason of their pathogenicity. In the first world war the results of treatment of 250 head wounds given by Cushing (1918) emphasized their importance; although these cases were not studied fully bacteriologically, it is clear from the records that these were the organisms responsible for nearly all the infections, and that of the 71 fatalities in the series " . . . no less than 43 were due to, or at least associated with, an intracranial infection—meningitis in 14, ventriculitis in 12, encephalitis—usually gas infection—in 9, and abscess in 8 . . . ".

* Working with a Grant from the Royal College of Surgeons of England.

In the second world war the marked effects of the sulphonamides and, particularly, of penicillin on these organisms made more apparent the frequency and persistence in wounds of other organisms relatively or absolutely insensitive to these agents, notably coliform bacilli, *Ps. pyocyanea*, and *Proteus*. Although these Gram-negative organisms had usually been considered relatively harmless, it became of consequence to know whether, with the powerful Gram-positive pathogens controlled, these other organisms would then become of pathogenic importance in wounds.

Cairns (1944), treating head wounds by local instillations of penicillin, noted the persistence of coliform organisms in the pus aspirated from the drainage tubes, and concluded that " the evidence to date is that it [Gram-negative pus] is harmless in brain wounds provided it has a free exit from the wound . . . however, organisms of the coliform group are not necessarily harmless in the cerebrospinal pathways, and if the pus were to leak into the ventricle severe consequences might arise ". The problem has been further studied in this paper from cases admitted to the Military Hospital (Head Injuries), Oxford, during the last year of the war when penicillin and one of the sulphonamides (usually sulphadiazine) were used prophylactically in war wounds of the head and spine.

CASE MATERIAL

Between June 6, 1944, and June 30, 1945, there were 20 cases of frank clinical meningitis in which Gram-negative organisms were grown from the C.S.F. and 2 further cases where the evidence suggested a minimal infection due to these organisms. Nineteen of these cases grew coliform bacilli from the C.S.F. and three *Ps. pyocyanea*; no growth of *Proteus* was recorded.

All these cases were in penetrating wounds of the head or spine and during this period 682 penetrating wounds of the head were admitted* and some 160 spinal wounds, most of which were penetrating. There was no instance of a meningitis due to Gram-negative organisms following a wound with intact dura.

In assessing the importance of these organisms there are certain difficulties. Although in some cases one type of organism was grown from the C.S.F. in pure culture and it was reasonably certain that this was the causal agent of the meningitis, since all the wounds were due to missiles, there were other cases where more than one type of organism was found, both Gram-positive and Gram-negative. In such circumstances it was difficult and in some instances impracticable to decide with any degree of certainty their relative pathogenicity.

It had also to be remembered that cerebrospinal fluid is an excellent culture medium and that contamination of the C.S.F. specimen, particularly by Gram-negative organisms, is not uncommon. Thus Wilson Smith and M. M. Smith (1941) found nearly 10 per cent of C.S.F. specimens examined by routine methods of culture contaminated, a quarter of them by *B. coli*. A coliform meningitis could not therefore be confidently diagnosed on the result of a single culture unless the growth was profuse or Gram-negative organisms were seen in the films. In the present series there were 13 cases of penetrating injuries where a few coliforms were reported in the C.S.F. on one occasion only in the absence of clinical signs of meningitis or increase of white cells and were considered contaminants; 3 further cases were also considered due to contamination where a few coliform colonies were grown from the C.S.F. during a staphylococcal or pneumococcal meningitis. These 16 cases have been excluded.

The routine method of culture employed was to plate out on ordinary nutrient agar and blood-agar and incubate aerobically and in many cases anaerobically as well. Owing to pressure of work, it was impossible at the time to carry out further typing of these organisms. The terms ' coliform bacilli ' and ' coliforms ' used in this article refer to lactose-fermenting Gram-negative rods.

CLASSIFICATION

The cases were subdivided as follows (*Table I*) :—

1. Coliform Meningitis (8 cases).—Coliform bacilli were the only organisms grown, clinical meningitis was present, and the cells in the lumbar C.S.F. reached 600/c.mm. or over, mostly polymorphonuclears. In *Cases* 1, 2, and 4 the organisms were grown on repeated occasions; *Case* 5 ran a fulminating course of a few hours and Gram-negative bacilli intra-and extra-cellular were seen in the films of the ventricular C.S.F., culture positive; *Case* 6 had only two lumbar punctures performed during a five-day meningitis, but the second showed the organisms in the film and on culture; *Case* 7 was a spinal wound which was freely draining C.S.F., and, although the evidence from cisternal puncture was not convincing, profuse coliform bacilli were grown from the wound and from the foreign bodies lying within the spinal canal.

Table I.—CLASSIFICATION OF CASES

CASES	NUMBER	RECOVERED	DIED
A. Cases of meningitis :—			
1. Due to coliform bacilli	8	4	4
2. Due to Gram-positive organisms and coliform bacilli	9	3	6
3. Due to *Ps. pyocyanea* (one in pure culture)	3	0	3
	20		
B. Cases of minimal coliform infection	2		
TOTAL	22		

In the two remaining cases the evidence was less certain. Thus only one positive culture was obtained from *Case* 3, on the first day of a recurrence of meningitis which rapidly subsided; and in *Case* 8, a spinal wound, one positive culture was obtained from the third lumbar puncture three days before death.

* Excluding the fractures of the paranasal sinuses without gross brain damage, there being no case of such injury complicated by this type of meningitis.

2. Meningitis due to Coliform Bacilli and Gram-positive Organisms (9 cases).—The bacteriological details are shown in *Table II*. All were cases of frank clinical meningitis with cells in the lumbar C.S.F. reaching over 2000/c.mm., mostly polymorphonuclears. In addition to cases growing Gram-positive organisms from the C.S.F., the finding in the films of Gram-positive cocci in the absence of growth of the organisms was also taken as evidence of the presence of a mixed infection, since it was considered that the use of sulphadiazine and penicillin would have inhibited this growth. *Cases* 10, 12, and 14 are such examples.

Evidence of the coliform infection was a positive culture on repeated occasions in 7 of the 9 cases. Of the two remaining cases, *Case* 13 had one positive culture from the ventricle in the first attack of meningitis; following a second operation later on, the bone-chips which were removed from the brain also grew coliforms, the meningitis recurred, and Gram-negative bacilli were seen in films of the lumbar C.S.F. (culture sterile): *Case* 15, with a heavily mixed infection, grew *B. coli* (Type I) from the ventricle on one occasion; the wound also grew the organism.

3. Ps. Pyocyanea Meningitis (3 cases).—In all 3 cases a gross meningitis was present. *Case* 18 was a pure *Ps. pyocyanea* infection; *Case* 19 grew clostridia as well; *Case* 20 was a mixed coliform amd *Ps. pyocyanea* meningitis.

4. Cases of Minimal Coliform Infection (2 cases).—A positive culture from the lumbar C.S.F. was associated in 1 case with meningitic signs without change in cytology, and in the other with increase of cells in the C.S.F. but without signs of meningitis. The probability of their representing cases of minimal infection will be discussed.

In the description which follows of coliform meningitis, the findings refer to those in the first group; where cases of the mixed group are used for illustration, this is indicated.

COLIFORM MENINGITIS

1. THE WOUND

Of the 8 cases of coliform meningitis in pure culture, 4 recovered and 4 died. Two of the 8 followed spinal wounds. Both the spinal wounds opened directly into the subarachnoid space and all the 6 head cases were ventricular wounds, either directly in 4, or by communication with the ventricle through a frontal aerocele (*Case* 1), or by reason of a foreign body embedded in the ventricular wall (*Case* 3). A summary of the type of wound sustained and its relationship to the onset of meningitis is given in *Table II*.

All the head cases received their main surgical treatment at a neurosurgical unit either overseas or in England, within forty-eight hours of wounding. Routine débridement of the wound was carried out, the track cleaned and explored, and all visible foreign bodies and those which could be felt and retrieved without undue damage to the surrounding brain removed. Deeply placed, isolated foreign bodies, not readily traceable along the existing track, were usually left alone, and it is interesting to note that three such examples occurred in this group. The wound was then dusted with one of the sulphonamide-penicillin powders (except sulphathiazole), and the scalp closed in two layers, the dura being left open; sometimes the wound was drained by a strip of guttapercha or rubber emerging through a separate stab incision in the scalp. A full course of penicillin intramuscularly and sulphonamides orally, generally sulphadiazine, was given from the outset.

The other noteworthy feature of these wounds was the high incidence of retained foreign bodies, usually bone-chips, after the initial operation. They were present in 7 of the 8 cases and it is significant that in the 1 case without them there was extensive brain destruction and blood-clot in the wound due to hæmorrhage from the anterior cerebral arteries.

Case 6/11332.—March 29, 1945, bifrontal wound. Severe hæmorrhage at operation within eighteen hours of wounding. A large metal foreign body was removed from the region of the right anterior clinoid process; fascial graft to dura; no foreign bodies remained. The patient developed meningitis and died five days later, death being undoubtedly accelerated by the brain damage and a coincident bronchopneumonia.

At autopsy the cavity between the dural graft and bony margins of the wound contained a moderate mass of blood-clot. Laceration was present in both gyri recti with disruption of the walls of the great longitudinal fissure, and it extended laterally to involve the olfactory tracts and posteriorly to the level of the optic chiasm, which was buried in clot. The medial part of the left corpus striatum, anterior part of the internal capsule, and inferior part of the head of the caudate nucleus were disrupted by hæmorrhage and a mass of clot 2 cm. by 1 cm. enclosed the thrombosed anterior cerebral arteries and entered the floor of the anterior horn of each ventricle. Generalized leptomeningitis. Bronchopneumonia.

The retained fragments lay within the spinal canal or the ventricle in 4 cases, within a paraventricular abscess in 2, and deep in the frontal lobes in 1. (*Table II.*)

The effect on the course of the meningitis of the presence or absence of these foreign bodies was striking. In *Cases* 2 and 7 they were removed at a second operation during the attack of meningitis, and both recovered; meningitis in *Cases* 1 and 3 followed a second operation for dural repair and removal of the foreign bodies and they also recovered. On the other hand, *Cases* 4 and 8 died where no second operation was performed and at autopsy the foreign bodies were found surrounded by pus: and *Case* 5 died where the wound had been reopened during the meningitis but the foreign body not removed.

The possibility of a meningitis flaring up as long as bone-chips are retained and the longevity of coliform bacilli in such circumstances was well illustrated by the following case.

Case 13/9699.—Aug. 21, 1944, frontal ventricular wound, with right hemiparesis and dysphasia. Operation performed fifty-four hours later and several, but not all, the bone-chips removed. Four days later, C.S.F. was escaping from one point in the wound; by Aug. 30 the wound was gaping and there was definite neck rigidity with temperature 101°. He became drowsy, his temperature rose to 103°, and the following day the wound was reopened and 22 bone-chips were removed from the track which led directly into the ventricle. Pulped brain in the wound grew coliforms and streptococci aerobically and a Gram-positive bacillus anaerobically. The ventricular C.S.F. grew coliform

bacilli and non-hæmolytic streptococci, and the spinal C.S.F. a few staphylococci.

During September he had bouts of fever up to 104°, was grossly confused, and at one time was extremely noisy and singing, but subsequently improved. In the early part of October he had several vomiting bouts accompanied by confusion, but he settled down and by the end of that month was convalescing, the meningitis having lasted forty-seven days.

Later, he developed fits, and an encephalogram on March 12, 1945, showed a local deformity of the left frontal horn associated with some retained bone-chips. By the next year the fits had increased in frequency, and at a third operation on April 1, 1946, twenty months after wounding, bone-chips embedded in the left frontal horn over an area 2 cm. by 1·5 cm. were excised, a cavity being left, the floor of which was formed by the caudate nucleus. No definite abscess was seen, but the bone-chips grew coliform bacilli of two types. The day after operation he had a mild bout of meningitis with low fever and neck stiffness, and Gram-negative bacilli were seen in films of the lumbar C.S.F., culture sterile. He was well by the tenth day. At the last follow-up in June, 1947, he reported that he was back at work as a teacher; there had been no fits since the operation.

2. CLINICAL FINDINGS

The meningitis was very variable in its time of onset, but the majority developed within three weeks of wounding.

No attempt will be made to describe a clinical picture in any way peculiar to this variety of meningitis, for what one was seeing was a severe pyogenic meningitis superimposed on a clinical condition previously determined by the brain wound and its immediate effects. Further operative procedures also coloured the picture. Nevertheless, there were certain features which, if not diagnostic of coliform bacilli, emphasized the ventricular wound and ventriculitis. The tendency to hæmorrhage in some cases described by Johnson (1947) was not found in this series, and it would appear that he was encountering a very virulent strain.

The meningitis (*a*) was fulminating; or (*b*) ran a continued illness of varying duration up to several weeks, characterized by acute flare-ups of the infection; or (*c*) was mild and of brief duration.

a. **Fulminating Coliform Meningitis.**—

Case 5/9387.—Aug. 3, 1944, left temporal ventricular wound with dysphasia and right hemiparesis; also wound in left axilla. At operation within twenty-four hours, the track was found to have entered the tip of the temporal horn; the skull fracture had opened into the anterior part of the bony auditory meatus at the junction with the middle ear. Superficial bone-chips were removed and the wound closed with a corrugated rubber drain, 6000 units of penicillin being injected into the track. Radiography also showed metal fragments in the left lung and his chest condition gave rise to anxiety as he developed surgical emphysema on the left side and a productive cough.

On Aug. 8 his temperature was 102° and respirations 26/min. The drain and sutures were removed from the head wound and there was a considerable leak of C.S.F. from the drain site. During that night he complained that his headache was more than usual and at 5.30 a.m. on Aug. 9 he suddenly collapsed: he was deeply comatose, with absent corneal reflexes. There was marked respiratory distress and his temperature rose to 105°. Needling of the left chest was negative. At 9.15 a.m. his condition was unchanged and his head wound bulging. An X-ray of the skull showed a metal foreign body lying to the right of the midline and probably impinging on the third ventricle. The lumbar C.S.F. was xanthochromic and under a pressure of over 300 mm. Later in the day, at 2 p.m., the wound was reopened but the extensive brain bulging made it difficult to recognize any track; the foreign body was not removed. A thin layer of subdural clot was present, but further burr holes did not disclose any extensive hæmatoma. No abscess was present. The left temporal horn was tapped: no increase of ventricular pressure, and the fluid contained 100 mg. protein, 1400 cells/c.mm., mostly polymorphonuclears, Gram-negative bacilli in the films and culture coliform bacilli. The patient died a few hours later, twelve hours after the sudden collapse.

At autopsy the main brain track was only 2·3 cm. in depth but posterior to it was the track of the M.F.B. (1·0 cm. by 0·6 cm.) which had passed through the internal capsule to lodge in the left wall of the third ventricle, embedded in soft reddish-brown tissue. Thick yellow pus was present in the basal cisterns and in the sulci of the right cerebral hemisphere. A thin layer of subdural clot lay over the left cerebral hemisphere. The ventricular system was slightly dilated, but macroscopically appeared normal; microscopically, œdema of the subependyma was present in the region of the foreign body.

A little blood was present in the left pleural cavity with collapsed consolidation of the left lung and pus around the foreign bodies, and early bronchopneumonia on the right.

This case conformed with four similar ones in the mixed group, all arising suddenly or appearing as a final flare of a previously moderate infection and running a fatal course in a matter of hours to a few days. In all there was a ventriculitis with turbid fluid in the ventricle and positive culture. In some there was a short prodromal period of a few hours of intense headache, but in others a sudden collapse, with a weak and rapid pulse up to 160/min., rapid and laboured respirations, mounting temperature to 104°–105°, maybe with rigors, pallor, and profuse sweating; neck rigidity was intense, the increase in tone later involving the limbs and abdominal muscles so that the extremities were held stiffly and the abdomen retracted. The mental state varied from deep coma to a very gross and noisy confusion.

b. **Acute Coliform Meningitis.**—This condition was commoner than the fulminating type, being seen in 6 of the cases, of which 3 died, 2 within a week of onset. In the 3 cases which recovered, duration of meningitic symptoms was 21, 41, and 90 days respectively. Attention may be drawn to the *continued raised temperature and pulse* seen in some cases; the temperature remained at 102°–103° with a rapid pulse up to 130/min. which in those cases that recovered took some time to settle down after the temperature. This toxic nature of the chart was more noticeable than with the commoner varieties of meningitis and may be a feature of this type of meningitis.

Characteristically during the longer duration of the infection in this group was the occurrence of *relapses* as illustrated in the following case:—

Case 2/9927.—Sept. 19, 1944, left ventricular occipital wound with dysphasia, right homonymous hemianopia, and a slight right facial palsy. At operation, thirty-six hours later, a deep track of 6 cm. was found into the ventricle; wound débrided and closed in layers. The wound healed, but on Oct. 3 C.S.F. began to leak from the wound edge, and forty-eight hours later there was onset of meningitis with temperature 100° and neck

Table II.—COLIFORM MENINGITIS: CLIN[ND PA

CASE IN TEXT	HOSPITAL NO.	WOUND	AGE AT INITIAL OPERATION	DETAILS OF RETAINED FOREIGN BODIES AFTER INITIAL OPERATION	ONSET OF MENINGITIS AFTER WOUNDING	DURATION [MENINGIT	
				1. Coliform Me			itis (8
1	9402	Transfrontal. Communicating with ventricle through a frontal aerocele	48 hr.	Bone-chips deep in frontal lobes removed at 13th week	14th week (9 days after 2nd operation)	22 days	180–5
2	9927	Left occipital, ventricular	36 hr.	Bone-chip removed from choroid plexus on 20th day	17th day	41 days	210–22
3	10958	Right fronto-parietal down to anterior horn of ventricle	28 hr.	Bone-chip attached to anterior horn of ventricle and removed, together with other bone-chips, at the 12th week	First attack on 17th day. Recurrence after 2nd operation, 12th week	(*a*) 11 days (*b*) 5 days	150–3
4	8840	Left parietal, ventricular.	< 24 hr.	At autopsy, 2 paraventricular bone-chips found, surrounded by pus	1st day	51 days	35–62
5	9387	Left temporal, ventricular	< 24 hr.	At autopsy, M.F.B. lying in 3rd ventricle, subependymal œdema, no pus	6th day	12 hours	100 ventri
6	11332	Transfrontal, ventricular	18 hr.	No retained F.B. (intracranial clot and extensive brain destruction)	5th day	5 days	120–5
7	10368	Spine. D.11, penetrating. Complete paraplegia	< 24 hr.	M.F.B. and several bone-chips removed from spinal canal on 24th day	19th day	90 days	70 (cister D
8	11459	Spine. D.9, penetrating. Complete paraplegia	11 hr.	At autopsy, large M.F.B. and ? grey wool in meninges and cord	25th day	6 days	1200–
				2. Meningitis due to Coliform Ba			nd Gr
9	9916	Right parasagittal, not ventricular	14 hr.	At autopsy, bone-chip lying 1 cm. from ventricle, no gross infection around it	23rd day	3½ days	300–
10	9389	Right parieto-occipital, ventricular	36 hr.	At autopsy, large bone-chip lying in choroid plexus, surrounded by pus	First attack on 9th day. Recurrence after A.E.G., on 53rd day	(*a*) 7 days (*b*) 30 hours	35– 200
11	10949	Left mandible—→Right posterior parietal, ventricular	7+ days	No retained F.B. (Developed a cerebral abscess.)	36th day	33 days	80–1
12	9175	Left occipital, ventricular	53½ hr.	At autopsy, M.F.B., 1 cm. in diameter, embedded in ventricle, cavity plugged with purulent exudate. Bone-chips in track	2nd day (sudden collapse on 4th day)	6 days (54 h after collaps	75–5
13	9699	Left frontal, ventricular	54 hr.	22 bone-chips removed from track, some in the ventricle, on 10th day; remaining bone-chips removed at third operation, 20 months later	First attack on 9th day. Recurrence after 3rd operation	(*a*) 47 days (*b*) 10 days	70–2 18
14	9639	Right parietal, track 1 in. deep, not ventricular	48 hr.	No retained F.B.	12th day	5 days	75–5
15	9835	Through-and-through right frontal—→ Right occipito-parietal, ventricular	3+ days	No retained F.B. (Extensive brain destruction.)	3rd day	7 days	Thi
16	11031	Right parieto-occipital, ventricular	22 hr.	Post-operative radiograph showed bone-chips 4 cm. deep. No autopsy	Within 48 hours. Terminal collapse 21st day	20 days (20 h after collap	200–
17	9498	Right parietal, ventricular	3 days	Large bone-chip lying in paraventricular abscess removed on 10th day	8th day	14 days	85–2

M.F.B., Metal foreign body; A.E.G., Air encephalogram; L., Lumbar C.S.F.; V., [ricular

rigidity, protein 500 mg. per cent, and 3952 cells/c.mm. in the lumbar C.S.F. (*Fig.* 312). He improved on chemotherapy, but relapsed on Oct. 8 with a temperature of 104° and rigor. The wound was reopened on Oct. 9, no pus was found, but mushy tissue was present along the track and a bone fragment embedded in the choroid plexus was removed. Wound closed after pericranial graft to dura. He improved after this second operation,

CLINICAL AND PATHOLOGICAL FINDINGS

C.S.F. FINDINGS (DAYS OF MENINGITIS)				SUBSEQUENT OPERATIONS	RESULT
Lumbar		*Bacteriology*			
Protein Range in mg. per cent	Cell Range per c.mm.	Coliform Bacilli	Other Organisms		
...itis (8 cases)					
180–550	80–5650	L.+ 2nd, 3rd, 4th, 6th, 9th. V.+ 18th	—	Fascial repair to dura for rhinorrhœa at 13th week. Bone-chips removed from frontal lobes	Recovered
210–2200	54–12,100	L.+ 7th, 17th. V.+ 7th, 8th	—	Bone-chip removed from choroid plexus of ventricle on the 3rd day of the meningitis	Recovered
150–300	1–600	— L.+ 1st day of recurrence	—	Fascial repair to dura at 12th week. Bone-chips removed from frontal lobes, one attached to ventricle and surrounded by greyish cystic fluid	Recovered
35–620	4–2040	L.+ 8th, 39th	—	No	Died
100 (ventricle)	1400 (ventricle)	V.+ 1st (G.—bacilli intra- and extracellular also seen in films)	—	Wound reopened on 1st day of meningitis. Necrotic brain sucked out. No abscess found. M.F.B. left in situ	Died
120–500	950–1550	L.+ 4th (G.— bacilli also seen in films)	—	No	Died
70 (cisternal) Draining	119 (cisternal) wound	C.+ 5th, 1 colony	—	M.F.B. and numerous bone-chips removed from spinal canal on 5th day of meningitis. Cultures from the depths of the wound, the M.F.B., and bone-chips, profuse growth coliforms	Recovered
1200–3500 Complete block	141–4930	+ 3rd	—	No	Died
...rm Ba...d Gram-positive Organisms (9 cases)					
300–700	++++	L. and V.+ 1st, 2nd, 3rd	L. and V. staphylococci on 1st	No	Died
35–70 2000	5–1100 17–760	— L. and V.+	— L. V. films, G.+ diplococci, many intracellular. No growth	No	Died
80–1200	60–9375	V.+ 14th, 31st. L.+ 31st	L. staphylococci and pneumococci on 1st, pneumococci on 25th. V. staphylococci on 4th, 14th, pneumococci on 25th	Developed cerebral abscess. Aspirated from the third week after wounding. Later exploration	Died
75–500	1400–5750	V. and L.+ on 4th, 5th. G.— cocci in films	V. G.+ cocci, some intracellular in films, 4th. No growth	Wound reopened on 5th day of meningitis; no abscess found. M.F.B. remained in situ	Died
70–270 180	10–2540 76	(*a*) V.+ 2nd (*b*) L. G.—bacilli in films. No growth	(*a*) L. few staphylococci 2nd. V. non-hæmolytic streptococci 2nd (*b*) —	Wound reopened on 2nd day of meningitis. 22 bone-chips removed from track and ventricle. Third operation twenty months later, bone-chips embedded in left frontal horn removed	Recovered
75–500	84–6197	L.+ 1st, 2nd	L. G.+ cocci in films, 1st, 2nd. No growth	No	Recovered
No Counts Thick yellow fluid		V.+ 6th (Type 1)	L. *Str. fæcalis*, staphylococci 4th, 5th, *Cl. sporogenes* 5th. V. G.+ anaerobes, staphylococci 5th	No	Died
200–1400	58–20,250	L.+ 3rd, 5th	L. hæmolytic streptococci twice on 19th	Wound repoened on 1st day of meningitis. No track or abscess found	Died
85–200	8–2260	L.+ 2nd, 5th, 6th	L. and V. *Cl. sporogenes* and *bifermentans* on 3rd	Wound reopened on 3rd day of meningitis and large bone-chip removed	Recovered

...ricular C.S.F.; C., Cisternal C.S.F.; G.—, Gram-negative; G.+, Gram-positive.

but relapsed again three days later and became semi-comatose. Turbid fluid was obtained from the right ventricle containing 35 mg. per cent protein, 403 cells/c.mm., and coliform bacilli on culture; the lumbar C.S.F. also showed a positive culture with protein 350 mg. per cent and 12,100 cells/c.mm. Although a spinal block developed on Oct. 14, he slowly improved, but on Oct. 30, after he had been apyrexial for a week

and the wound which had again leaked C.S.F. had been dry for three days, he had his third clinical relapse and the spinal block increased. Following this he made a slow but steady recovery, the dysphasia and hemianopia remaining. The meningitis lasted forty-one days.

Follow-up: In March, 1946, he reported that he was labouring. He was having headaches, but the dysphasia was improving, and in the opinion of his doctor he was fit for more skilled work.

A third clinical point to which reference may be made was the development of *fine twitchings* over the body. These were seen in *Case* 4 of this group and in four of the mixed infection cases, all with marked ventriculitis. They were continuous and often involved the muscles of all four limbs; they could be superimposed on a generalized rigidity or a paretic limb and at times would be accompanied by facial

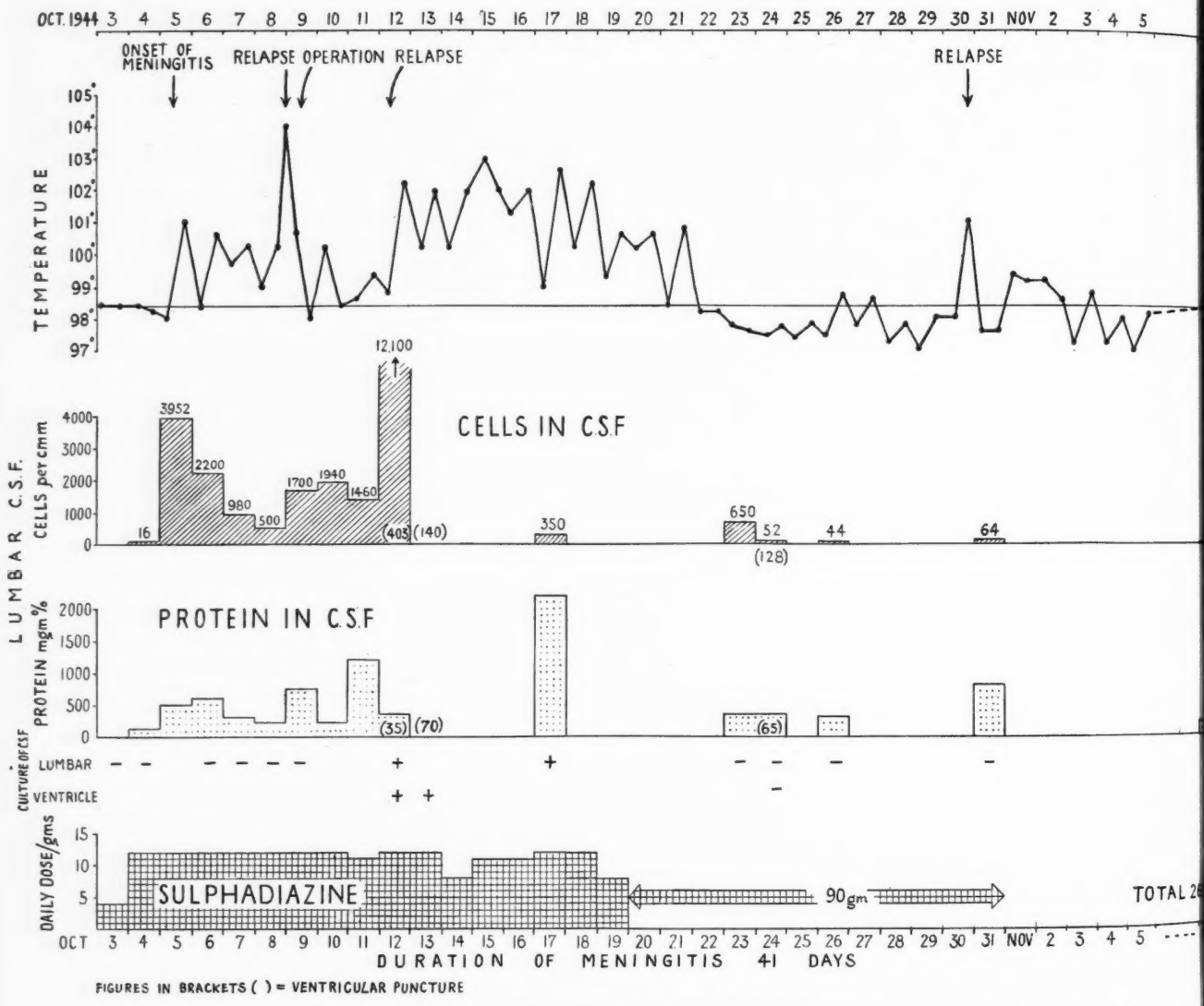


FIG. 312.—*Case* 2/9927. The temperature, C.S.F. changes, and sulphadiazine treatment in a case of coliform meningitis. Duration of meningitis 41 days with three relapses.

These relapses of meningitis were common. Undoubtedly the persistence of an intracranial focus with intermittent leak into the ventricular system accounted for some of these relapses, but, as the case report above shows, relapse also followed removal of such a focus; this was also seen in *Case* 7, where a third relapse occurred after an interval of no less than seventy-nine days, during which time the patient had been making a steady improvement. A further contributory factor in such cases must be resolution of local blocks in the cerebrospinal pathways with release of infective material into the general subarachnoid space.

twitches, nystagmoid jerks of the eyes, and in one instance by a definite rolling movement of the eyes.

In a case of *Ps. pyocyanea* ventriculitis (not in this series) following excision of a cerebral abscess secondary to an ear infection, intermittent twitchings of all four limbs were observed. The B.P. was normal and blood-urea 34 mg. per cent. An E.E.G. done during such an attack was grossly abnormal, showing high-voltage spike activity (F.16–24/sec.) and 2–4 sec. waves; these were recorded from all parts of both hemispheres and represented continuous *grand mal* activity.

These twitchings would appear to be cortical in origin, either from irritation of the cortex by

pus or interference with its nutrition; the fact that they are seen in cases with ventriculitis presumably means no more than that with such an infection there is ready dissemination over the cortex. Twitching of the facial muscles and eye movements are, of course, seen in basal meningitis with spread of the pus to involve the cranial nerves as they leave the skull.

c. **Mild Coliform Meningitis.—**

Case 3/10958.—Feb. 15, 1945, right frontoparietal wound with hernia cerebri and disorganization of the right eye. At operation, twenty-eight hours later, the frontal lobe was found to be grossly destroyed and most of it was sucked away. The brain appeared foamy, but no cultures were taken. Numerous intracranial bone-chips were removed to a depth of 6 cm. The patient made a satisfactory convalescence, and a week later the C.N.S. was normal to routine examination. He was taken off sulphadiazine on March 1, but on March 4 had a mild meningitis which lasted eleven days, the protein rising to 300 mg. per cent and cells 600/c.mm., mostly polymorphonuclears, all cultures sterile.

Radiography showed that deep bone-chips were still present, and on May 11 fascial repair of the dura was carried out. Bone-chips were removed from each frontal lobe, one being attached to the wall of the anterior horn of the ventricle and surrounded by a little greyish-looking fluid. The following day there was a recurrence of the meningitis, the C.S.F. which the day before operation had contained 59 mg. protein and no cells, now showing 160 mg. protein, 262 cells/c.mm., half of them polymorphonuclears, 1750 R.B.C.s/c.mm., and culture coliform bacilli. The bone-chips were sterile. This recrudescence quickly settled after five days and the patient then made a satisfactory convalescence.

Follow-up: In June, 1947, he reported that he was well and employed in light mechanical engineering. The only sequelæ were a little difficulty at times in concentration and memory.

3. THE CEREBROSPINAL FLUID

The fluid withdrawn by lumbar puncture was invariably under high pressure, 300 mm. water or over, and cloudy in appearance. Yellow coloration of the fluid, as reported by earlier writers, was also observed in a few, but the use of intrathecal penicillin obscured subsequent changes. The occurrence of a low ventricular pressure in the presence of increasing changes in the C.S.F. or a worsening of the clinical state was of grave prognostic importance.

Protein.—A high protein value was recorded in several cases and was particularly striking in comparison with the cell-counts, which were relatively low. *Fig.* 313 shows the protein values and cell-counts in the lumbar fluid in 6 head cases punctured at the onset of clinical signs of meningitis. In the presence of head wounds protein values must be offset against any previous increase due to existing brain damage, but in the 3 cases where protein content before onset of the infection was known there was still a very marked increase at the commencement of the meningitis. In all 6 cases the protein at onset was over 100 mg. per cent, 3 of them showing values of 360, 500, and 670 mg. per cent respectively. No strictly comparable figures with those in other types of pyogenic meningitis are available, but Merritt and Fremont-Smith (1937) give a figure of 100–500 mg. per cent in 60 per cent cases of meningococcal meningitis at the first puncture, and Smith (1947) in 11 cases of pneumococcal meningitis (mostly children) punctured within twenty-four hours of onset of clinical signs found the protein value above 150 mg. per cent in all of them, 4 of them with values of 350 mg. per cent or over. Globulin was present in considerable excess.

Higher protein values were recorded later during the illness. Ventricular protein sometimes reached a high figure and *Case* 1 was remarkable in that on the eighteenth day of the meningitis the protein in the ventricle was 800 mg. per cent with only 156 cells, mostly polymorphonuclears, the lumbar protein during the course of his twenty-two-day infection never rising above 550 mg. per cent, although at one time a block developed.

It was also noticeable that in the cases which recovered, the protein took a long time to return to normal, remaining up many weeks after the infection was passed and the cells had returned to normal or near normal.

Cells.—These were predominantly polymorphonuclear, usually over 80 per cent in the acute phase. In comparison with the protein, their numbers were not unduly high, as can be seen from *Table II* and *Fig.* 313; in 4 of 6 head cases the figure at onset of meningitis was 1500/c.mm. or under, and during the illness only 1 case, during a relapse, showed a very high cell-count on one occasion of 12,100 cells/c.mm.

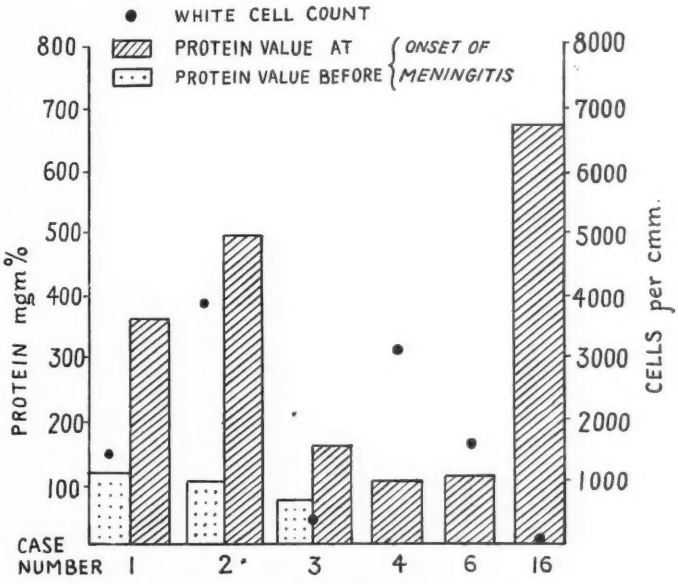


FIG. 313.—C.S.F. changes at onset of coliform meningitis (6 cases).

Red cells in moderate numbers were seen in some cases, but in no case was an obviously blood-stained fluid withdrawn which could be satisfactorily ascribed to the effects of the infection alone.

Spinal Block.—Three of the 6 cases of coliform meningitis following head wounds developed a block as judged by the Queckenstedt test responses. All came on relatively late; in *Case* 1 complete block occurred on the eleventh day after onset of meningitis; in *Case* 2 on the ninth day; the block in

Case 4 was not demonstrated until the thirty-sixth day, although it was certainly present before this time. Gumming up of the subarachnoid mesh was not surprising in the absence of an efficient antibacterial agent and where the meningitis was long continued. There was some indication that repeated lumbar punctures helped in preventing the onset of block and in aiding its subsequent resolution, as the following 2 cases show.

Case 1/9402.—Aug. 8, 1944, transfrontal wound, with frontal aerocele. The patient made a good initial convalescence, but an encephalogram on Sept. 18 showed that the aerocele communicated with a normal right ventricle; three bone-chips remained deep in the frontal lobes. At the beginning of November, rhinorrhœa was reported and a bilateral fascial repair to the frontal dura, together with removal of the intracranial bone-chips and insertion of a tantalum plate, was performed on Nov. 9. On Nov. 18, nine days after operation and the day after coming off chemotherapy, the patient developed meningitis. A complete block occurred on the eleventh day of the meningitis, the protein range in the lumbar C.S.F. to that time having been 180–450 mg. per cent and white cells 300–3650/c.mm., R.B.C.s 0–5250/c.mm. On the eighteenth day, using penicillin as a 'tracer', 10,000 units were injected into the right ventricle; none was recovered from the lumbar theca eighteen hours later.

This block cleared, and on the twentieth day the pressure was 130 mm. and 20 c.c. fluid were withdrawn easily by lumbar puncture with a protein of 550 mg. per cent and 2630 cells/c.mm. In the interval between block and clearance the patient had had four spinal punctures, two cisternal punctures, and one ventricular tap, this latter showing a protein of 800 mg. per cent. The patient recovered.

Ten months after leaving hospital he reported that he was back at his job as a clerk but was having headaches and memory difficulty.

Case 4/8840.—July 1, 1944. Left ventricular parietal wound, numerous bone fragments being removed from the track and ventricle at operation within the first twenty-four hours. A post-operative radiograph showed that three bony fragments remained. From the first day he had signs of meningitis and for ten days was very confused. The clinical condition fluctuated and there were three bursts of cells in the spinal fluid, suggesting leaks from a ventricular abscess. By July 11 ventriculitis was clinically established. From the onset of the infection this patient had daily lumbar punctures for three weeks, until on July 24 they had to be discontinued as the lumbar muscles were swollen. During this time the protein range was 35–420 mg. per cent, cells 4–2040/c.mm., and R.B.C.s 6–2300/c.mm.; no block was present. The next lumbar puncture was on the thirty-sixth day, when complete block was found, with a protein of 620 mg. per cent, 735 cells/c.mm., and no R.B.C.s. This block remained complete, the last examination on the forty-fourth day showing a protein of 620 mg. per cent and 10 cells/c.mm. The patient died a week later.

The interesting features of the blocks in these cases were the late onset, the ninth to tenth day or later, and the low range of protein and cell-counts. These findings may be contrasted with those of *Cases* 12 and 16 with meningitis due to Gram-positive and Gram-negative organisms, which developed blocks within thirty-six hours of onset, the fluids clotting rapidly, with protein over 1000 mg. per cent and abundant pus cells.

It would seem, then, that in pyogenic meningitis one must consider two types of block; that of very early onset which is purely mechanical from the aggregate of large numbers of cells with fibrin and other protein exudate and which in the presence of a rapid and effective method of combating the organism responsible would tend to resolve, and that of later onset, from the tenth day onwards, which may occur with protein and cell values relatively low, is slow of resolution (if it clears at all), and can be associated pathologically with the organization of the exudate, collagen appearing microscopically early on.

4. PATHOLOGY

Autopsy was performed in *Cases* 4, 5, 6, and 8. The appearances conformed to those of a generalized pyogenic ventriculitis and meningitis and no finding was recorded which could be accounted characteristic of coliform bacilli. The successive changes seen in the meninges and ventricles according to the duration of the infection were of interest and are described, reference being made to some of the relevant autopsy findings in the mixed group of meningitis.

Wound.—In *Case* 5 death occurred twelve hours after onset of the infection. The main temporal wound track was hæmorrhagic and œdematous and contained much fragmented brain tissus; posterior to this was the track of the metal foreign body (1 cm. by 0·6 cm.), which had passed through the internal capsule to lodge in the left wall of the third ventricle surrounded by soft, reddish-brown necrotic tissue. These findings were no doubt contributed to by re-exploration of the wound shortly before death.

Case 4 died after a prolonged meningitis. A cerebral hernia of pinkish-grey material presented through the dura beneath the scalp. Microscopically the contained cerebral tissue was grossly disintegrated, œdematous, and heavily infiltrated with foam cells and containing some bone-chips surrounded by mononuclears but not obviously the seat of active infection. Two paraventricular bone-chips were found, however, surrounded by pus.

The spinal track of *Case* 8 was filled with pus and led down to the body of D.8. The cord was completely pulped and an elongated jagged piece of metal (1·2 cm. by 2 cm. by 2 cm.) surrounded by grey wool was filling the meningeal defect. Focal areas of thick extradural pus were present and the theca throughout its entire length was distended by pus.

Case 6, as mentioned earlier, had no retained foreign body; the extensive clot and the brain destruction which was present along the track has been described.

Brain.—In these cases the brain was full, with flattening of the convolutions. Tonsillar herniation was present in three of the four. If the autopsies of the mixed group were also considered it was seen that internal herniation only occurred in about half the cases and hippocampal herniation was as common as descent of the tonsils through the foramen magnum. The decompressive effect afforded by the existence of a bony defect beneath

the wound, however, should be remembered. There were no intracerebral abscesses.

Œdema of the subependymal tissues was present and also of the cerebral cortex subjacent to the meninges, with perivascular cuffing of the penetrating vessels. This latter feature was not seen in the spinal cord, though peripheral œdema was evident.

Meninges.—All parts of the leptomeninx were affected and thick greenish pus was seen, not only distending the basal cisterns, filling the interpeduncular fossa, and lying alongside the pituitary body, but also extending in the sulci over both hemispheres, particularly along the lateral fissures and over the cerebellar lobes where the pus spread out from the cisterna magna. Thicker layers of pus seen in certain places were due either to local conditions, such as the presence in *Case* 5 of a thin layer of subdural clot over the left hemisphere which gave the appearance that the distribution of the pus was confined to the opposite side; or to the anatomical size of the subarachnoid space as in the basal cisterns; or to the result of the posture of the patient in bed, resulting in local collections of pus over the occipital lobes and a heavier distribution over the dorsal as compared with the ventral aspect of the spinal cord.

Microscopically, no thickening of the leptomeninges was seen in the fulminating case at twelve hours, the exudate being predominantly polymorphonuclear leucocytes and cellular debris. Macrophages and collagen appeared early, however, and at the seventh day in *Case* 6 the exudate consisted of lymphocytes and macrophages; it was thicker, more gelatinous, and greyer in appearance, the choroid plexus of the fourth ventricle and the lateral recesses being extensively involved and matted. The leptomeninx was thickened, giving a milky opacity to the vertex and obscuring the pus lying in the sulci. At the fifty-first day in *Case* 4 the exudate contained mainly small round cells.

Ventricles.—Dilatation of the lateral ventricles was already distinguishable in the twelve-hour case, and here, although the ependyma appeared macroscopically normal, subependymal œdema was present microscopically in the region of the foreign body. The later changes in the ventricles were seen in some cases of the mixed group where the infection had lasted a day or so longer; by then the ependyma was a little thickened, roughened, finely granular, and microscopic ulceration was seen, well marked in the cerebral aqueduct. Purulent exudate was free in the cavities.

Ventricular changes were gross in the long-continued cases: in *Case* 4 the ventricles were markedly dilated and the ependyma was obviously thickened, swollen, and pink, with a glistening surface except for focal patches of easily separated purulent exudate; in the occipital horn was an ependymal abscess 2·5 cm. in diameter and here the ependymal epithelium was absent over a considerable area, the subependymal tissue being infiltrated by chronic inflammatory cells, with cuffing of the vessels by mononuclears. With such ependymal destruction, part of the ventricle may be converted into a closed pyocephalus by the ventricular walls becoming adherent to one another. This seemed most prone to occur at the tip of the anterior horn or the junction of the posterior horn with the vestibule, as shown in the mixed group.

It is noteworthy that in all 4 cases of the series where death followed within a few days of onset of infection the cerebral aqueduct was patent. In the later cases 2 showed occlusion, 1 (*Case* 4) by partially organizing thick tenacious pus, and 1 (*Case* 11) by organized exudate resulting in complete stenosis.

5. TREATMENT

The treatment of the wound at the beginning, the local use of sulphonamide-penicillin powder, and the routine administration of penicillin intramuscularly and sulphadiazine orally for an average of five days, or longer if the condition of the patient warranted it, has been mentioned previously. The value of this prophylactic therapy for Gram-positive infections is well established, but it is considerably more difficult to evaluate its use for Gram-negative infections. The evidence suggested that it did hold some coliform infections in check since in *Cases* 1 and 3 symptoms of meningitis commenced within forty-eight hours of discontinuing the sulphadiazine.

In treating the actual meningitis, all cases received very full courses of sulphadiazine; two of them received sulphamezathine as well, though there was no evidence that the course of the infection was thereby altered. A course of intramuscular penicillin was commonly given together with intrathecal penicillin until the true nature of the infecting organism was no longer in doubt. It is probably true that the sulphadiazine damped down the virulence of the infection, but recovery of the 4 cases could not be ascribed to an obvious curative effect of the drug. Thus *Case* 3 was a mild meningitis; in the other 3 cases all had large courses of the drug, up to 200 g. in seventeen days, but during the longer duration of their infections, 22, 41, and 90 days respectively, all had several relapses with increase of cells in the spinal fluid.

As previously indicated when describing the wounds in these cases, the presence or absence of retained foreign bodies or necrotic material in the brain was of particular significance in the prognosis of the meningitis, and their successful removal was considered the major factor responsible for the recovery of the 4 cases.

CASES OF MINIMAL COLIFORM INFECTION

It is a reasonable assumption that, after wounding, organisms enter the cerebrospinal fluid pathways for a varying duration of time more often than the subsequent incidence of meningitis would suggest, and that, depending on many factors, some indication of which has already been given, one would expect to find some such gradation of the relationship between host and organism as follows: (*a*) Transient entry of organisms into the C.S.F. shortly after wounding, to disappear again without changes in the cell-count of the C.S.F. or clinical signs of meningitis; (*b*) transient appearance of organisms in the C.S.F., with increase of cells but without clinical signs; (*c*) the addition of mild

clinical signs of brief duration; and (*d*) frank meningitis of increasing severity.

It is believed that the following 2 cases may be considered examples of minimal infection.

Case 21/8815.—Bullet wound of head sustained on June 27, 1944, involving the right Rolandic area and entering the ventricle. At operation, forty-two hours later, the wound was excised and the track débrided, a deep mass of bone-chips removed, a 0·3-cm. hole being seen in the lateral ventricle. Penicillin (10,000 units) was instilled into the cavity and the wound closed. A post-operative radiograph showed that some of the deeper bone fragments and M.F.B.s remained but that the greater number had been removed. A culture of the bone-chips grew a Gram-positive aerobic bacillus and coliform bacilli.

A lumbar puncture on the day of operation showed only 2 cells and a protein of 60 mg. per cent; culture not done: four days after operation the protein was 100 mg. per cent with 22 W.B.C./cm., 45 per cent polymorphonuclears, and 1550 R.B.C.s/c.mm.; Gram-positive cocci were seen in the films and on culture a few Gram-negative bacilli and one colony of *Staph. albus*. He made an uninterrupted convalescence with no clinical sign of meningitis, and on the sixth post-operative day another lumbar puncture showed a protein of 110 mg. per cent, no cells, and sterile culture. He received a course of sulphadiazine for ten days.

Follow-up: February, 1947, patient well but left arm and leg weak. He had not yet found employment.

Case 22/9557.—This man sustained a through-and-through frontal wound on Aug. 11, 1944. At operation, forty-four hours later, both frontal lobes were found extensively destroyed; fascial graft placed over torn dura. After operation he remained disorientated and drowsy, but on the fifth day his temperature rose to 101° and he had a little neck stiffness. Lumbar puncture showed a normal pressure, protein 75 mg. per cent, 9 lymphocytes and 700 R.B.C.s/c.mm., a few coliform bacilli on culture. He continued his sulphadiazine and intramuscular penicillin and by the seventh day his temperature was normal again, and on the eleventh day the C.S.F. was cell free. He made a steady convalescence. Culture of the brain track at operation was sterile, but the bone-chips from the frontal lobes grew a few staphylococci. The small number of red cells in the C.S.F. and the late onset of signs is against entry of blood into the C.S.F. following operation being the cause of the clinical disturbance.

Follow-up: In May, 1947, he reported that he was well apart from occasional headache and had been employed as a steel worker for the last two years.

Thus the first case showed organisms in the C.S.F. with increase of cells only four days after initial operation where bone-chips growing coliform bacilli had been removed from a head wound, while the second case showed brief clinical signs of a meningitis and a few coliform bacilli on culture of the C.S.F. five days after wounding.

MENINGITIS DUE TO COLIFORM BACILLI AND GRAM-POSITIVE ORGANISMS

In 4 cases of this group, treatment with sulphonamides and intramuscular and intrathecal penicillin resulted in the early disappearance of the Gram-positive organisms from the cerebrospinal fluid, leaving the coliforms apparently in pure culture and clearly playing a major role in the subsequent course of the meningitis (*Cases* 9, 12, 13, 17).

In *Case* 16 the patient was making a satisfactory recovery from a coliform meningitis when he suddenly succumbed within twenty hours on the twenty-first day from an overwhelming hæmolytic streptococcal infection.

In 2 cases (*Cases* 11, 15) there was a heavily mixed Gram-positive infection and the associated coliform bacilli were of little importance.

In the remaining 2 cases (*Cases* 10, 14) Gram-positive cocci were present in the films but the culture grew coliform bacilli; it is not possible to determine the relative importance of these organisms in relation to the meningitis.

Excluding the 3 cases where the meningitis was due mainly to the Gram-positive organisms, the mortality of the remainder was 50 per cent, the same as in the pure coliform group.

The type of wound and the relationship of foreign bodies to the infection ran closely parallel to that seen in the previous group. Seven of the 9 wounds were ventricular, and in 6 of them foreign bodies were retained. Of the 3 recoveries, 2 followed successful removal of ventricular bone-chips. The other one (*Case* 14) was of particular interest since it was the only case in the whole series where a frank meningitis associated with coliform bacilli developed in the absence of retained foreign bodies or extensive brain destruction; and here the performance of a lumbar puncture seems to have been a precipitating factor.

Case 14/9639.—Aug. 19, 1944, right parietal wound with a transient left paralysis of the face and arm and no loss of consciousness. Operation at forty-eight hours showed a superficial track 2·5 cm. deep, from which all bone-chips were removed, subsequently confirmed by X-ray. The wound healed by first intention, and on Aug. 29 intramuscular penicillin and sulphadiazine were discontinued. However, the same day he developed Jacksonian attacks. Lumbar puncture was performed the next day which showed 3 lymphocytes/c.mm. and 50 mg. per cent protein. On the following day (Aug. 31) he had a temperature of 101°, pulse 120/min., was shivering and complaining of headache and backache, no neck rigidity. The C.S.F. protein had risen sharply to 500 mg. per cent with 6197 white cells, mostly polymorphonuclears, no red cells, intra- and extra-cellular Gram-positive cocci in the films and culture coliform bacilli. The lumbar C.S.F. on Sept. 1 also showed a few Gram-positive diplococci in the films with a culture of coliform bacilli. He was treated with intrathecal penicillin and sulphamezathine and was well again after five days.

In May, 1947, he reported that he was doing light clerical work and still improving.

Although the signs of meningitis followed the day after a lumbar puncture, the onset of the Jacksonian sensory attacks previous to this on stopping the penicillin and sulphadiazine, and the finding of both Gram-positive and Gram-negative organisms in the C.S.F. suggest that the puncture flared an infective focus within the head.

PS. PYOCYANEA MENINGITIS

Three such cases occurred in this series, all fatal within a fortnight of onset. The organism was grown in pure culture in *Case* 18, was a mixed infection with Gram-positive anaerobes in *Case* 19, and developed in *Case* 20 during the course of a

coliform meningitis and was undoubtedly the cause of death.

Case 20/11140.—March 2, 1945, penetrating spinal wound in the right suboccipital region with weakness of both arms and paræsthesia. At operation within thirty-six hours a foreign body was removed from the depths of the wound, which was then packed with penicillin powder and vaseline gauze. After operation the patient ran a low pyrexia and had some headache; by March 9 the temperature was 102° and he was becoming a little drowsy. On removing the wound packing, there was a flow of yellow pus and C.S.F.

Meningitis began clinically on March 13, with T. 103° and lumbar C.S.F. containing 420 mg. per cent protein, 1090 cells/c.mm. mostly polymorphonuclears, and culture coliform bacilli. He improved on penicillin, sulphadiazine, and regular dressings to the wound, at which times sequestered pieces of atlas and axis were removed. The C.S.F. again grew coliforms on the fourth day.

The wound, which had grown coliforms, became infected with *Ps. pyocyanea* on March 20. The patient's general condition was good and the wound became clean, though leakage of C.S.F. from it was intermittent. For the next two months he made steady improvement, lumbar punctures showing a sterile C.S.F. but a varying cell-count of 40–3270/c.mm., a block developing. On May 15 he had a relapse, the temperature rising to 103°; he became confused, incontinent, and developed nystagmus to the right and twitching of the facial muscles. The lumbar C.S.F. now showed 220 mg. per cent protein, 4022 cells/c.mm., mostly polymorphonuclears, and culture *Ps. pyocyanea*. Despite energetic treatment, including streptomycin (410,000 units into the theca and ventricle from May 26 to 29), he died on May 29, fourteen days after the relapse. *Ps. pyocyanea* was recovered on several occasions from the lumbar and ventricular C.S.F., but, in relation to streptomycin, it is significant that the ventricular C.S.F.s examined on the last two days were sterile.

Ps. pyocyanea appears to differ from coliform bacilli in that it is certainly a secondary invader and infection of the meninges is usually of very late onset—in the 3 cases the onset of meningitis was 34, 46, and 77 days after wounding respectively—and the mortality is extremely high.

DISCUSSION

Meningitis due to coliform bacilli has been considered uncommon and the majority of cases reported describe the very fatal form seen in young infants. Thus, Barrett, Rammelkamp, and Worcester (1942), in an extensive review of the literature, found 108 cases of coliform meningitis reported to that date, 65 of them in infants under 3 months of age. Only 13 cases had been reported in patients over 25 years of age. The origin of the infection of these cases in civilian life was often indeterminate, but in some an infective focus was found in the ear or urinary tract. Recently, Evans (1945) and Kremer (1945) have drawn attention to meningitis due to these organisms arising as an unfortunate complication of spinal analgesia.

Following wounds, the overwhelming pathogenicity of the Gram-positive organisms seen in the 1914–18 war almost totally obscured the possibility of the Gram-negative organisms as infective agents. The experience of surgeons in the latter part of the recent war, however, suggests that with present methods of treatment by penicillin and sulphonamides these organisms are now of considerable importance. Harley, Baty, and Bowie (1946) concluded that the Gram-negative organisms were anything but innocuous in low-grade infections of compound fractures of the limbs occurring in the East, and Johnson (1947), from the same theatre, described the findings in several fatal cases of meningitis following head wounds due to virulent strains of *E. coli*. From the European theatre Botterell and Magner (1945) described 11 cases of *Ps. pyocyanea* meningitis complicating 400 penetrating head wounds. Florey, Ross, and Turton (1947) studied the effect of Gram-negative infection on 73 wounds, mainly limb wounds, treated in this country and found that interference with tissue repair was the main complication; no toxæmic effect was observed.

In this paper a review has been made of 20 cases of meningitis associated with Gram-negative organisms in the C.S.F., in a series of 682 penetrating head wounds and 160 spinal wounds from North-west Europe. The complications arising in the first 354 head cases of this series were described by Cairns, Calvert, Daniel, and Northcroft (1947); in these, meningitis of all types developed in 35, and 10 of them were associated with Gram-negative organisms. One may conclude from these figures that the incidence of meningitis after penetrating head wounds is 10 per cent and that the Gram-negative organisms, mostly coliform bacilli, are partly or solely responsible for about a quarter of them, a position which reflects the efficacy of treatment of the Gram-positive infections with penicillin and sulphonamides.

The time at which these organisms gain access to head wounds is difficult to determine and records of the bacteriological flora of such wounds shortly after injury are scanty. *Ps. pyocyanea* is definitely a late invader and almost invariably secondarily introduced, as shown in the 3 cases reported here and those of Botterell and Magner (1945).

Coliform bacilli are commonly found in head wounds by the third day, and the 3 cases in this series where meningitis was declared within the first forty-eight hours suggest an earlier date (*Cases* 4, 12, 16). Ascroft and Pulvertaft (1947) examined the bacteriology of 125 head wounds and obtained a positive culture of coliforms in 9 of 50 cases within three days of wounding and in 12 of 75 wounds over three days old. Scott Thompson (Cairns, 1944) obtained a positive culture of coliforms in 7 of 23 head wounds over three days old, Ives and Reddy (Johnson, 1947) in 20 out of 52 wounds examined, and Botterell and Magner (1945) in 25 of 94 penetrating head wounds. The evidence here is that although *B. coli* may quickly gain entrance to a wound and produce an early meningitis, the infection commonly extends inwards at a later date from the surface, from an unhealed wound, a cerebral fungus, or along a pre-existing drainage track. Thus in *Cases* 2, 5, and 7 leakage of C.S.F. from a point in the wound or the drainage site occurred within forty-eight hours of the onset of meningitis. Alternatively, these organisms may be carried in along with foreign bodies, become walled off, and remain quiescent until flared into activity following an operation or spinal puncture. *Cases* 1, 3, and 13 flared after a further operation.

The relation to spinal puncture requires further consideration. The possibility of these organisms being introduced at the time of a lumbar puncture or with the intrathecal penicillin must be remembered. Botterell and Magner (1945) considered that two of their *Ps. pyocyanea* cases were due to this latter factor, but there was no evidence in the cases recorded here that the penicillin was the vehicular factor of the meningitis. On the other hand, the performance of spinal puncture seemed to be a precipitating factor in 3 cases. *Case* 10 had a meningitis (cultures sterile) from which he recovered; six weeks later a fatal ventriculitis followed a cisternal encephalogram which clearly flared the infection, a bone-chip being found in the ventricle at autopsy surrounded by pus. In *Cases* 9 and 14 onset of meningitis due to Gram-positive and Gram-negative organisms followed a lumbar puncture, although on the evidence this was considered a precipitating rather than a causal factor. Meningitis arising after lumbar puncture in the presence of a past history of infection or evidence of abscess or foreign bodies near the ventricle is a complication which should be borne in mind; where this investigation has to be carried out in such circumstances it is advisable to have the patient on sulphadiazine and kept in bed under observation for forty-eight hours afterwards.

Onset of meningitis after entrance of these organisms will be determined by their virulence, by the physical state of the patient, and by the nature of the wound. It is clear from these cases that this last factor is an important one, and that cerebral tissue possesses a natural resistance to these organisms: but in the presence of a wound opening the main cerebrospinal fluid pathways, particularly the ventricle, where foreign bodies are retained or necrotic material remains to any degree near to or within these pathways, meningitis may arise. The fact that coliform bacilli infrequently produces meningitis under civilian conditions of life may be due, in part, to the resistance offered by a healthy cerebral system in the presence of potential infection.

It follows that the main requirement in the successful treatment of these cases is attention to the wound. Prophylactically every effort should be made at the first operation to remove all bone-chips and necrotic tissue and aim at complete closure of the wound without drainage. In treating the actual infection the fact that, even allowing for individual differences, all the cases in this series where foreign bodies had been or were removed lived, whereas all those cases in which they had remained died, justifies the conclusion that where such a meningitis supervenes and a foreign body is known to be lying near or in the ventricular system it should, if possible, be removed forthwith and that this procedure will be the main factor in deciding the prognosis of the case.

Sulphadiazine should be given and is certainly effective to a varying degree in some cases. Barrett et al. (1942) considered from their review that the sulphonamides were definitely beneficial and mentioned five recoveries attributed to the use of these drugs. Since then McLendon and Mitchell (1941) and Hollis and Baty (1944) have each reported the recovery of a young infant on this therapy: Strong and Edwards (1945) treated a coliform meningitis following a G.S.W. spine with sulphonamides, but stated that the successful outcome was due mainly to drainage of a spinal subdural abscess and removal of the bullet; and Crawley (1946) described a further case of recovery in an adult. It may well be that if a higher concentration could be safely reached in the cerebrospinal fluid it might be more effective: urinary infections due to this organism respond well and there a high concentration is reached. Sulphadiazine in the doses used by mouth can reach a figure of 10–15 mg. per cent in the blood but is frequently less, since concentration depends on absorption and the low blood estimations found in some of these patients may have been due to poor absorptive power of patients gravely ill. Furthermore, loculation of infection by adhesions in the more protracted cases may prevent the drug reaching all parts of the system in adequate concentration.

With this in mind and believing that the alkalinity of the solution is the main danger, Kremer (1945) employed intrathecal solutions of carefully buffered sulphadiazine in doses of 100 mg. in the treatment of one of his cases following spinal analgesia, with some success. The margin of error, however, is very small and this method is unlikely to be pursued now that streptomycin is becoming available. Nevertheless, it is advisable to ensure that a high concentration is reached in the early days of the infection by using a continuous sulphadiazine intravenous drip with alkali.

Ecker (1945) recommended the use of urea by mouth in addition to sulphadiazine and treated one case of *B. coli* meningitis in this manner with recovery. Urea has been used for a long time as a dressing for wounds, its strong proteolytic action exerting a solvent action on pus and necrotic material. Its trial in meningitis followed the demonstration that urea increased the solubility of sulphonamides locally applied, and the investigations by Tsuchiya, Tenenburg, Clark, and Strakosch (1942, a, b) of its additional action as an 'anti-inhibitor' of sulphonamides. Using strains of *E. coli*, these workers showed *in vitro* that urea and sulphonamides together exerted a greater inhibitory effect than the latter alone, even in the presence of para-amino-benzoic acid.

Contamination of wounds with coliform bacilli is common and resulting meningitis by comparison infrequent, so it is difficult to evaluate any prophylactic benefit of urea and sulphonamides locally applied; Ecker (1946) has applied this to some head wounds without incident. Its value when used orally has not yet been established; the method was not employed in this series.

The recent demonstration of the action of streptomycin on Gram-negative organisms has been followed by preliminary clinical trials. It failed to save the two cases in this series where it was tried, but only in one was it used in any concentration and that in the later stages of a mixed coliform and *Ps. pyocyanea* meningitis—though it is significant that there the last ventricular fluids examined were sterile. Alexander (1946) has reported its successful use in one case of *B. coli* meningitis secondary to a bacteriæmia

of indeterminate aetiology; the white cells in the spinal fluid reached 900/c.mm. and protein 124 mg. per cent. In Shields's (1946) case of *B. coli* meningitis in an infant, recovery followed the use of streptomycin, but the cell increase in the C.S.F. was small and mostly lymphocytes. The report of the National Research Council (1946) of 1000 cases of infection treated with streptomycin included 14 cases of Gram-negative meningitis other than those due to *Hæmophilus influenzæ*; 3 were due to *B. coli*, of which 1 recovered and 2 'improved'; in all there were 5 recoveries in the series, 5 'improved', and 4 deaths.

There are some important factors to be remembered in the clinical use of the antibiotic. Abraham and Duthie (1946) have shown that the activity of streptomycin varies with the *p*H, and this explains the fact that its efficacy is diminished in the acid medium of pus or of long-continued inflammation. The work of Buggs, Bronstein, Hirshfeld, and Pilling (1946) on the *in vitro* action of streptomycin on bacteria, and the experience of Adcock and Plumb (1947) in treating urinary infections due to Gram-negative bacilli, show that not only may the various types of coliform bacilli differ widely in their sensitivity to streptomycin, but that whilst under treatment resistant strains may develop. It would appear, then, that success in streptomycin therapy will be dependent on early treatment and control of the initial doses of the antibiotic according to the sensitivity of the particular bacterial strain; sulphadiazine in addition may be effective if there is not a prompt response.

Previous reports show that the mortality of coliform and *Ps. pyocyanea* meningitis met with in ordinary life is very high. Barrett et al. (1942) in their review found that the mortality of *B. coli* meningitis was 78 per cent and that 9 cases which recovered from the acute illness subsequently developed hydrocephalus, thus giving only a 14 per cent complete recovery. Kerman, Perlstein, and Levinson (1943), in reporting a case of *Ps. pyocyanea* meningitis, found previous reports of 55 cases in the literature with an overall mortality of 58 per cent; however, cases reported since that date by Evans (1945), Kremer (1945), and Vuylsteke (1947) show a higher mortality.

Following war wounds, 2 of the 11 cases of *Ps. pyocyanea* meningitis described by Botterell and Magner (1945) recovered: in this series all 3 *Ps. pyocyanea* cases died. Coliform bacilli were not so lethal, 4 of the 8 cases of this series treated by a combination of surgery and sulphadiazine recovering, and the same 50 per cent mortality was estimated amongst the cases in the mixed group of meningitis where the coliforms were judged to have played an active part. This lower mortality of coliform meningitis as compared with that found in civilian life may have been influenced by two factors: there is the possibility that one was encountering organisms of moderate virulence gaining a foothold only under the exceptionally favourable conditions which war wounds afford; also the age of the patient may be important, for in civilian life *B. coli* meningitis is commonest in infants, and in them, as Wilson (1929) has pointed out, agglutinins in the blood are low, whereas in older people, probably as a result of repeated subclinical infections, 'normal *B. coli*' agglutinins are found.

The development of blocks in the subarachnoid space has been mentioned, and it was suggested that one could distinguish two types—those of early onset due to the thick purulent exudate blocking the spaces, and those of later onset due to organization of this exudate. An effective antibiotic used in the early stages of the infection will do much to obviate this complication, but, as shown in the treatment of pneumococcal meningitis with penicillin, it may still occur.

The beneficial effects of removal of the purulent fluid in pyogenic meningitis is clear from the successes attending this procedure in the days before chemotherapy and antibiotics. Thus Quincke (1895) advocated drainage by lumbar puncture; Dandy (1924) had some recoveries following continuous cisternal drainage, and Symonds (1925) irrigated the spinal sac with saline through cisternal and lumbar needles in a case of staphylococcal meningitis with success. Spurling (1928) employed surgical drainage through a laminectomy.

To remove purulent fluid and exudate not only from the spinal sac but from the basal cisterns and the subarachnoid spaces over the vertex is mechanically a very difficult problem. Although Merritt and Fremont-Smith (1937) state that meningitis may be regarded as an empyema of the ventricular-arachnoid system it is an empyema not of a single sac but of several communicating, and in some situations poorly communicating, ones. Considering the intricacies of the space one is trying to drain, then it would seem that success is only likely to follow those measures which most imitate the natural circulation of the C.S.F. The cerebral ventricles constitute a natural reservoir and, as shown from the autopsies in this series, the cerebral aqueduct is not occluded in the early stages of the infection. Kolmer, Rule, and Madden (1929), in a series of experiments on dogs, showed that cerebro-cisternal-lumbar lavage could be effective, but were unable to obtain successful results in man, probably because blocks already existed in the system when treatment was first undertaken. A preliminary ventriculo-lumbar lavage followed by a continuous ventricular drip and lumbar drainage is a possibility, but even with antibiotics the risk of introducing other organisms by irrigation methods is not inconsiderable. Alternatively, the results of 'forced drainage', using intravenous hypotonic solutions (Kubie and Raten, 1933), suggest that repeated lumbar punctures and slow drainage of the cerebrospinal fluid combined with a high fluid intake would help, provided treatment is commenced early before the foramina around the fourth ventricle become hopelessly matted; the evidence from the cases of block in this series suggest that these punctures do help in the prevention and the resolution of spinal block. Whatever the method, C.S.F. pressures should be kept within upper normal limits, since to maintain a low pressure is to invite further adhesions in the subarachnoid space. The danger of internal herniation following lumbar puncture in meningitis is small provided there is no cerebral abscess present, an observation which has been repeatedly made in the past. Pneumococcal and coliform meningitis

do not seem to show any particular propensity to abscess formation; on the other hand, staphylococcal and streptococcal infections may be complicated by abscess (Smith, Schiller, and Cairns, 1946), and in such cases considerable caution would have to be exercised. Nissim (1947) has employed spinal wash-outs through a single lumbar-puncture needle, though how extensive this lavage can be is not yet certain; he demonstrated an important secondary effect of removal of the purulent fluid in restoring the osmotic pressure of the C.S.F. to normal levels.

These subarachnoid blocks may determine not only a protracted illness from hydrocephalus or recurrent infection due to loculation and periodic release of infected debris, but by sealing off cerebrospinal pathways prevent adequate diffusion of antibiotics or chemotherapeutic agents; it is certain that further attention will have to be directed to this complicating factor in meningitis.

SUMMARY

1. Twenty cases of meningitis associated with Gram-negative organisms in the C.S.F. after 682 head and 160 spinal wounds from North-west Europe, 1944–5, are described. Eight cases were due to coliform organisms alone, and 9 to Gram-positive organisms as well. There were 3 cases of *Ps. pyocyanea* infection. Two further cases are described which may represent minimal coliform meningitis. No case of *Proteus* meningitis occurred.

2. The present importance of the Gram-negative organisms in head wounds is stressed. In a series of penetrating head wounds from the European theatre, the incidence of meningitis was 10 per cent and Gram-negative organisms were present in the C.S.F. in a quarter of them.

3. The high proportion of ventricular wounds and retained foreign bodies in this series suggest that these factors are important in the development of the meningitis. All patients in whom the foreign bodies were removed, even at the height of the meningitis, recovered.

4. The mortality from coliform meningitis treated by surgery and sulphadiazine was estimated at 50 per cent; all three *Ps. pyocyanea* cases proved fatal.

5. Comment is made on the methods of treatment available, and particular attention is drawn to the necessity of preventing and treating subarachnoid block in pyogenic meningitis.

My thanks are due to Dr. G. T. Western, who was responsible for most of the bacteriology of these cases; to Miss McLarty for the preparation of the charts; to Dr. P. Daniel, who performed the autopsies; and to Professor Sir Hugh Cairns for his advice in the preparation of this paper.

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A REVIEW OF SURGICAL METHODS IN THE TREATMENT OF ESSENTIAL HYPERTENSION

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THE soundness of British surgery is accepted by all. This soundness is founded on the corner stone of conservatism. The value of a surgical procedure must be well established before it receives the blessing of British surgery. Thus many pitfalls and blind alleys are avoided. Is there not some danger that conservatism may be carried too far?

There is an immense literature on essential hypertension which grows daily. Little of this emanates from British sources. In regard to the surgery of the matter there is still less to report. There are accounts of many hundreds of operation results from America—almost nothing from Britain. A notable exception is the thoughtful and fine paper of Fitzgerald (1946) on a small group of cases.

It is because of this dearth of British post-operative material that this paper is written. It emanates from a South African hospital where the teachers, teaching, and tradition are predominantly British.

MATERIAL

This paper is based on the study of the first 50 private patients operated on by the author. The work has all been carried out in a private nursing home where the staff has been trained in the investigation, handling, and nursing of these patients.

The work was inspired by a visit to Boston in 1944 where the writer had the great privilege of watching the work of Dr. Reginald Smithwick and his team at the Massachusetts General Hospital. As Dr. Smithwick put the matter: he is engaged on a great experiment and the more workers in this field scattered over the globe, the more data would be gleaned towards a solution of the problems underlying hypertension. The series of cases here reported was begun early in 1945, so that the longest follow-up is just over two years. The surgery of essential hypertension is of so recent origin that no follow-up data are yet complete enough on which to make positive statements; nevertheless, much is to be gained from a careful study for even short periods.

AETIOLOGY

A vast amount of work has been done and is in progress to try and find the cause for this symptom-complex. The aetiology is as yet unknown. There are many diseases associated with elevation of the blood-pressure. Goldring and Chasis (1946) wisely decline to classify these, stating that classification cannot be made when the cause is unknown. They merely list the conditions in which blood-pressure is raised: certain renal diseases, coarctation of the aorta, some suprarenal, pituitary, and ovarian tumours, periarteritis nodosa, specific hypertensive disease of pregnancy, essential hypertension, renal arterial obstruction.

In 1898 Bergman coined the word 'renin'—a pressor substance on which much experimental work has been done. It has, however, not yet been recovered from human blood nor has hypertension resulted from the transfusion of blood from hypertensive into normotensive persons.

Goldblatt's lasting claim to fame is that by the experimental production of sustained hypertension he has stimulated a receptive world.

In regard to the role of the kidney it has been well said that this organ is the victim rather than the villain of the piece (Fishberg, 1944).

The place of unilateral renal disease has recently been well reviewed by Braasch and Barker (1947), who state with authority that experimentally produced hydronephrosis will not in itself cause hypertension; where nephrectomy produces sustained lowering of the blood-pressure removal of infection is probably the beneficial cause; that infection may produce a circulatory renal imbalance which leads to the production of a pressor substance which causes the hypertension. They thus subscribe to the views of Page and his associates (1941). Braasch and Barker found that two years after nephrectomy results in regard to the lowering of the blood-pressure were good in 41 per cent of cases, fair in 16·4 per cent, poor in 33 per cent, and that 10 per cent were dead.

Smithwick* states that nephrectomy may reduce the blood-pressure in the young and then usually for a period only. The views of Page et al. noted above would supply the explanation as to why pyelonephritics respond so well as a rule to operations for hypertension. Max Peet (1947) gives the opinion that essential hypertension arises from a congenital abnormality in the autonomic nervous system whereby excessive responses are evoked by normal stimuli. Such stimuli acting on the abnormally sensitive splanchnic nerve centres cause a more or less continuous renal ischæmia. Some support is given to this view by the fact that there is often a family history of hypertension. Taking the matter by and large the proximate cause of this fell disease is still unknown and it is a symptom-complex which has to be treated.

As there may be many causes for this varying group of symptoms it is readily apparent that results of treatment will not be uniform. A good working hypothesis is that primarily there is a neurogenic basis for the disease, the abnormal stimuli arising in the brain. These can be interrupted by splanchnicectomy. Later, however, as the erstwhile reversible kidney changes become fixed, a stage is reached when there is so much organic renal damage with its attendant production of pressor substances, that cutting of the nerve pathway is no longer effective and the heightened blood-pressure is irreversible.

* Personal communication.

Now the condition is really one of essential hypertension.

THE ACHIEVEMENTS OF MEDICINE

In the many unsatisfactory chapters of medicine, there are few that make such dismal reading as the treatment of essential hypertension.

The sufferer has been bled, starved, put to bed, sent from home, totally deprived of salt (for which tribes have gone to war), purged, advised to give up work, alcohol, and tobacco, and subjected to the loss of endless other amenities. Periodically new régimes, diets, and drugs have a popularity and then are heard of no more. For how many years was it not the custom to deprive hypertensive patients of red meats and salt? Fishberg (1944, b) puts the matter in his masterly manner: "No dietary treatment is known which has a specifically favourable effect on essential hypertension. The patient with essential hypertension, as long as there is neither cardiac nor renal failure, may partake of all the usual dietary constituents. However, he should eat only as much as is necessary to maintain his strength and avoid any excess. The restriction to the necessary quantity should be extended to total calories, total volume of fluids, protein and salt".

Walter Kempner (1946), in an illuminating publication of effects of the rice–fruit–sugar diet in the treatment of kidney disease and hypertension, states: "The consensus of opinion at the present time is that dietary treatment is useful in kidney disease, but of little or no value in hypertension without obvious renal involvement."

Goldring and Chasis (1944, a) in 1944 summed up the prevalent view in their book on hypertension: "The diet in uncomplicated hypertension requires no essential change from the normal. No matter which single factor in the rice diet is of greatest importance in compensating the various manifestations of renal metabolic or excretory dysfunction, it remains true that in 203 of 322 patients, on most of whom other forms of therapy have previously been tried, the rice diet led to objective improvement. Of a 100 patients with primary kidney disease, 65 per cent showed improvement on the rice diet. Of 222 patients where a diagnosis of hypertensive vascular disease was made, 62 per cent improved. . . . It would not be right to use such a case as an argument against sympathectomy".

Kempner concluded that the sequence of surgical treatment and dietary treatment should be reversed, since the treatment with the rice diet, if it proves to be ineffective, can simply be discontinued. It must be said, however, that the above dietary is exacting and that many people could not tolerate it. Also, any effects it produces are at the stage of the disease when time is of value and there is often some degree of urgency if catastrophe is to be averted.

An Editorial in the Centennial number of the *Journal of the American Medical Association* (1947, **134**, 457) concludes as follows: "Further work on this therapeutic approach is needed. In spite of the overwhelming evidence of value of a special dietary regimen agreement on constituents of the diet and the indications and contra-indications has not been obtained. Careful clinical observations under controlled conditions are necessary before the dietary regimen can be considered worthy of general adoption in clinical practice".

Of drugs much the same may be said. There is none which produces any but transient effect and others may be dangerous, such as thiocyanate.

Summing up this section, medical and surgical measures should be used as complementary and not as rival methods of treatment in hypertension.

THE CASE FOR SURGERY

Essential hypertension is public enemy number one. It is four times as deadly as cancer (Poppen and Lemmon, 1947). Of those who attain the age of 40 years, 40 per cent will die of hypertension, and after 45 this scourge is responsible for a greater mortality than all other diseases put together.

Conservative measures being able to achieve so little, surgeons the world over began to turn their attention to the matter. Danielopolu and a Portuguese surgeon Pereira (1927) gave early attention to attack on the sympathetic system. The early major developments in the field have been due to American surgeons, amongst whom the names of Craig (1932), Adson (1935), and Crile (1938) stand out. Craig and Adson developed the operation of supra- or infra-diaphragmatic division of the splanchnic nerves. Crile removed the cœliac ganglion. Peet (1940) in 1933 devised and performed the operation of bilateral supradiaphragmatic resection of splanchnic nerves and ninth to twelfth thoracic ganglia. This procedure has stood the test of time, and Peet uses much the same operation to-day and his experience is probably as extensive as anybody's. Further reference to his work will be made. R. H. Smithwick (1940) in 1938 devised the operation of lumbodorsal ganglionectomy with splanchnicectomy, a combination of the Peet with the Craig–Adson operations. K. S. Grimson (1941) began to practise near-total sympathectomy.

THE PHYSIOLOGICAL BASES FOR SURGERY

The elastic function of the arteries resides almost entirely in the aorta and its larger branches, and, as Fishberg (1944, a) points out, diminution in the elasticity of these vessels raises the systolic but lowers the diastolic pressure. The pressure in the capillaries is very low. The peripheral resistance is largely due to the highly developed muscular system of the arterioles, and it is now universally accepted that hypertension is produced by functional vasoconstriction affecting more or less of the arteriolar system. To produce this effect vasoconstriction must be very widely spread and must involve the splanchnic area. Fishberg summarizes by stating "that the available evidence thus indicates that the vasoconstriction producing hypertension is evenly distributed through at least the great territories of the abdomen, the skin, and the limbs".

It was the development of this knowledge which led surgeons to endeavour to lessen the vasoconstriction or peripheral resistance by removing part of the nerve-supply responsible for the spasm, and as knowledge grew so surgical procedure changed to meet the better physiological understanding. It is

apparent also, in passing, that spasm may abate or increase, which will account for the established fact that hypertension is at first occasional—a better word than transient—and only later tends to permanency. In fact this lability of the blood-pressure is the surgeon's greatest ally and once reactivity is lost the outlook for surgical betterment is diminished. It is thus apparent that to achieve success a wide arteriolar area must be denervated and the modern operation seeks to remove as much of the sympathetic vasoconstrictor supply to the visceral vessels as is possible, and also the vasoconstrictors to the lower limbs. This entails removal of the splanchnic nerves and also the lower thoracic and first and second lumbar ganglia. The last two ganglia mentioned are responsible for the entire vasoconstrictor supply to the lower limbs. The extent of the denervation in the Smithwick operation is shown in *Fig.* 314.

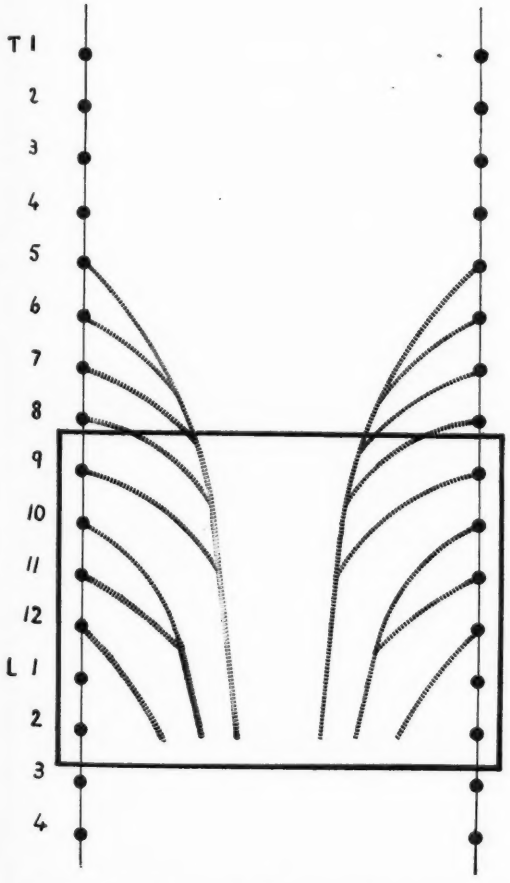

FIG. 314.—A diagram showing the minimal extent of the Smithwick operation. The sympathetic trunks are shown by continuous lines and the splanchnic nerves by dotted lines.

The procedure is carried out on both sides. It is fundamental that the nerve removal shall be preganglionic to avoid the sensitization of the myoneural junctions to circulating adrenine.

All prospective male candidates for surgery are to be warned that whereas potency will in all probability be unaffected, removal of the first lumbar ganglion on each side removes the function of ejaculation, and sterility results. That this is not absolute is indicated by various authors (Poppen and Lemmon, 1947). In the writer's experience it approaches so near to being a rule, that it is the surgeon's duty to present it as such to the patient. The operations have no effect on the sexual functions or fertility in women.

How is Benefit brought about by Surgery?—This question is one that does not admit of an accurate answer. When the patient gets out of bed after the operations have been done, there is often a considerable fall in pressure due to the dilated splanchnic and lower limb vascular territories being flooded with blood. This postural hypotension is combated by applying bandages from feet to knees and a well-fitting corset. The patient finds that when standing still there is a tendency to or an actual faint. In the vast majority of cases accommodation occurs in a month or two and the bandages can be discarded one at a time and later the corset. Yet the extraordinary fact is that whereas 80 per cent of cases show a worth-while fall in blood-pressure after surgery, almost without exception patients are benefited symptomatically, in their well-being, response to effort, ability to return to work, etc. It has been said that this results from the constant internal venesection which follows operation.

The following case illustrates these features :—

Case B.P. 87.—Referred by Colonels Agranat, Craib, and Susman.

A British Army Colonel, aged 46. He had suffered for many years from headaches which periodically attained extreme severity. He had become increasingly irritable. He was on service in the campaigns in North Africa. His condition became steadily worse until ultimately he was hospitalized suffering from congestive cardiac failure of a severe grade. He continued in hospital for months in this state. When the congestive failure had improved sufficiently he was referred for consideration for surgery. His physicians felt that the prognosis without operation was grave in the extreme, and the patient, a man of culture and high mental attainment, stated that he preferred shooting himself to continue living in a state where he could not get out of bed without precipitating cardiac failure. The findings at this time were cardiac enlargement—heart/chest ratio being 7 : 12. Eye grounds showed Grade 1 changes. The kidney excretory function was only fair, the blood-urea being around 50 mg. per 100 c.c. There were no casts, but albumin ++ in the urine.

The average lying blood-pressure was 176/120 mm. Hg.

The sedation test result was 168/110.

The picture was most unattractive and the tests showed that little if any benefit in the blood-pressure could be hoped for from operation. As the patient was a medical man and in desperate plight, well able himself to appreciate the risks and issues involved, operation was carried out in November and December, 1945. During the first stage no pulse was anywhere detectable before the incision was made. Tilting the table away from the heart produced some improvement. The second stage was uneventful. A year after operation the patient returned for re-check. He felt well, had put on 60 lb. in weight, and was able to walk for miles. He had even gone hunting and was engaged in farming.

The heart/chest ratio was $5\frac{3}{4}$: $12\frac{1}{4}$. The electrocardiogram was normal. The renal excretion tests were better, but the blood-urea remained about the same. (*Fig.* 315.)

	Pre-operative	*1 year after operation*
Average lying pressure	176/120	146/114
Sedation test	168/110	140/80
Type	I	I

This case shows a Group 4 result—one which Smithwick considers as not worth while in terms of the fall in blood-pressure, and this can be seen in the superimposed blood-pressure studies in *Fig.* 315. Yet the change in this man was remarkable—from a querulous invalid, he was restored to good health with reversal of the cardiac changes. Any hypertensive series shows many similar cases.

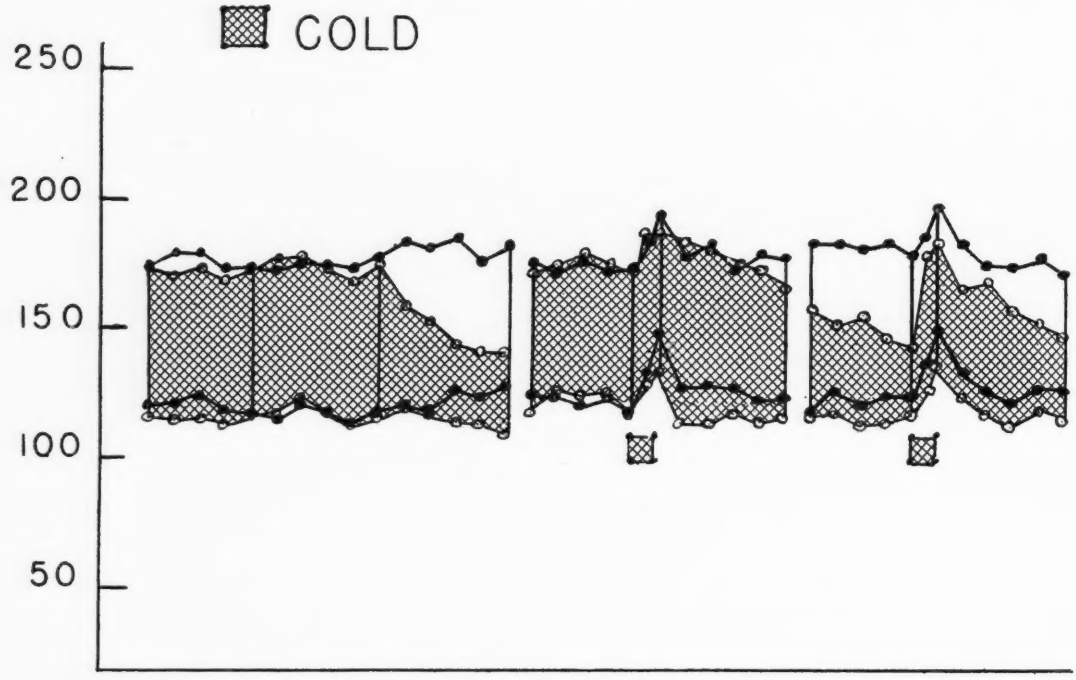

FIG. 315.—The postural and cold tests of *Case* B.P. 87. Pre-operative between black lines; Post-operative, cross hatched.

Of course the kidneys are by operation deprived of all vasoconstrictor nerves and the removal of renal arteriolar spasm may be important. It is of interest that many people lose the feeling of internal tension (inability to relax), irritability, etc., after operation and this has been attributed to denervation of the suprarenal glands.

The Choice of Cases for Surgery.—It is generally agreed that :—

1. The young hypertensive will do well after operation.

2. The old arteriosclerotic with hardened arteries, a wide pulse pressure, and fixed hypertension is not suitable for surgery.

3. The intermediate group—which presents many problems as to whether or not surgery should be advised.

Max Minor Peet (1947), after his immense experience, presents the matter succinctly with commendable and weighty simplicity: "In summary the following are our criteria for operation: A patient below 54 years of age; a more or less continuously elevated blood-pressure, with a systolic pressure of over 170 and a diastolic pressure above 105; a non-protein nitrogen below 45 mg. and preferable below 40 mg. per 100 c.c.; a relatively well-compensated heart and a relatively normal cerebral function. Exceptions are occasionally made, especially in the older age group an in cases with a slightly higher non-protein nitrogen. These exceptions are generally made because of incapacitating symptoms such as excruciating headaches, or when there is evidence of an otherwise hopeless malignant hypertension."

It is interesting to quote Peet again (1946), in a slightly earlier publication. The author states the patient's age at the time of operation has no influence on the post-operative survival. The extent of the hypertensive disease process is the important factor in survival. A reasonable operation risk is presented by any patient under 60 who is not in congestive failure, who has a non-protein nitrogen of below 45 mg. per 100 c.c.; and who has had no major cerebral accident within the previous month. One in every five cases of malignant hypertension can have life prolonged by operation; 60 per cent of patients who have had a stroke may expect prolonged life with no further stroke after operation. Hypertensives with ocular fundus changes, but no evidence of heart, cerebral, or renal involvement, may expect excellent results from operation.

There is a group who tolerate high blood-pressure well, they live out their lives with no symptoms or complications. They should be left alone. If increased blood-pressure is discovered during routine examination, complete investigation should be done. If the elevation is only moderate and producing no symptoms, and there is no retinal, cardiac, cerebral, or renal involvement, then only medical measures and periodic re-examinations are

necessary. Should any evidence of progression be found the patient becomes a candidate for surgery. The intelligent management of the hypertensive patient requires a knowledge of the complete clinical profile of the patient. These then represent the considered experience of Peet and it would be impossible to make matters clearer. Certain cases in all series are disappointing and therefore the criteria of some other surgeons are more exacting. It is doubtful whether much is to be gained by too meticulous pruning. In the present state of knowledge it would seem that the criteria given above cannot be bettered.

Should operation be undertaken for symptoms alone? Should the surgeon operate to try and save sight for instance? The answer must be in the affirmative, but only if by so doing rules are not broken. In other words the case must conform to the general rules of operability as laid down by each for his own guidance.

The work of Reginald H. Smithwick has had an immense influence on world opinion. It is indeed a privilege to visit his clinic; and now that he has attained professorial status at a comparatively early age, it can be anticipated with confidence that much will accrue to surgical knowledge through his work, more particularly in the field of the autonomic system which he has done so much to illuminate. Smithwick's criteria for the selection of cases of hypertension for operation are more exacting, and by follow-up studies he has succeeded in demarcating certain combinations of physical signs and laboratory data at certain age groups which give almost uniformly poor results from operation (1944, a). He has been able to formulate certain rules which should be observed if disappointing results are to be avoided.

What can Surgery achieve?—It is of great interest to review the results of these two famous pioneers and authorities in this field of surgery. Peet (Peet and Isberg, 1946) reports on 437 cases treated by his supradiaphragmatic operation followed up for five to eleven years. Serious organic disease existed in 82 per cent before surgery. 57·5 per cent were alive when the follow-up was made. 17 per cent of the whole group showed symptoms and retinal changes only, and of these 95 per cent were living five to eleven years after operation. 77 per cent of these had maintained normal or significant falls in blood-pressure. Noteworthy improvement had occurred in electrocardiograms, eye grounds, and kidney function. Symptomatic improvement followed operation in a vast majority of the cases both in those who sustained significant falls in blood-pressure and in those who did not. About one-third of cases which had severe heart or kidney damage prior to operation did not survive the five- to eleven-year period. A remarkable feature of this series of cases is comprised by those who were operated on while in the dreaded accelerated phase (malignant hypertension). 19 per cent were alive after five to eleven years. These cases almost all die within a year if surgery is withheld.

Smithwick (1947, a) reports a series of 439 cases followed for one to eight years after operation. All the cases had reached the stage of continuous hypertension. Only 3 per cent showed no cardiovascular damage before operation. The cases were unselected, yet over 60 per cent showed significant fall in blood-pressure and improvement in cardiovascular damage. The 70 per cent of the group which could be regarded as selected showed a 75–85 per cent chance of a significant fall in blood-pressure and improvement in the cardiovascular status. When it is remembered that this series contains many cases who, prior to operation, had sustained strokes, coronary thrombosis, congestive failure, etc., it is astounding to read that the overall mortality (operative and due to causes not related to the hypertension) over a period of one to eight years was just over 1 per cent, 98·8 per cent being alive at the time when the follow-up was made. It is apparent from the analyses of cases of these great scientific surgeons that under the near perfect systems they have evolved the surgery of hypertension holds few terrors. It must, however, be stated with all possible emphasis that if such surgery be undertaken without proper selection of cases, adequate training and knowledge, and proper team work, here, as in any branch of surgery, the whole picture would be changed at once with disastrous outcome.

On the medical side and right up to the moment Palmer (1947), from the Massachusetts General Hospital, Boston, states that there are no tests by which the outcome of surgery in hypertension may be predicted, that there is a diminishing return of maintained normal or near normal blood-pressure as time goes on, but that the 25 per cent of sustained significant lowerings of blood-pressure were at least twice as good as the results obtained by medical means in 100 cases.

The writer goes on to say relative to surgery that " the expense in discomfort, time, and money (though not in risk to life) is comparable to having a coronary thrombosis ". Using the same standard of ratiocination it could be argued that the expense and discomfort of the exhibition of penicillin in pneumonia renders its use not worth while. As Smithwick (1947, a) so courteously and aptly states, deploring the absence of comparable groups of cases treated by medical regimen, " these results are open to as much criticism as anyone wishes to level at them ". If the blood-pressure was not lowered at all by the Smithwick and Peet operations, the benefit to the patient by relief of symptoms and the improvement in electrocardiograms, eye-ground changes, general well-being, etc., would amply justify the procedure.

Specific Nomenclature.—Smithwick (1944, c) grades hypertensives into three types (*Fig.* 316). The width of the pulse pressure in the resting horizontal position is compared with half the diastolic pressure. The figures are taken from the postural test which is done after two or more days' rest in bed.

> Pulse pressure less than half the resting diastolic pressure—*Type* 1.
>
> Pulse pressure more than half the resting diastolic pressure but less than half the diastolic pressure, plus 19—*Type* 2.
>
> Pulse pressure more than half the diastolic pressure, plus 20—*Type* 3.

The importance of Smithwick's typing is that it gives a good indication of a cross-section of the arterial bed.

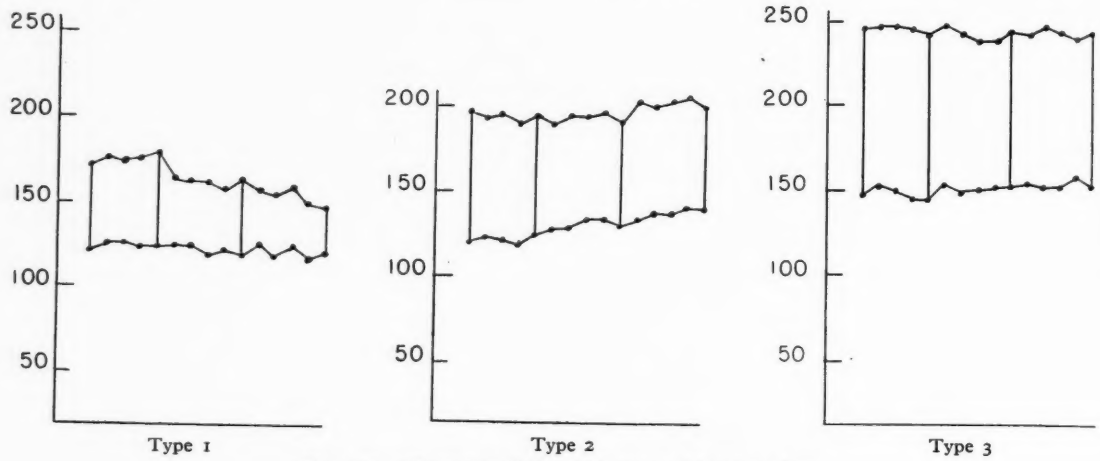

FIG. 316.—Illustrating Smithwick's types of hypertensives.

Type 1 gives the best prognosis. The narrower the pulse pressure, the better the outlook. A wide pulse pressure suggests fibrosis and less lability in the vascular tree.

The average of the first five readings in the postural test is the average resting blood-pressure. It is a figure of paramount importance, for it is the standard with which all future readings are compared. The diastolic is the important figure as its level determines the load on the heart when the strain on that organ should be least. Thus the term average resting pressure is often used.

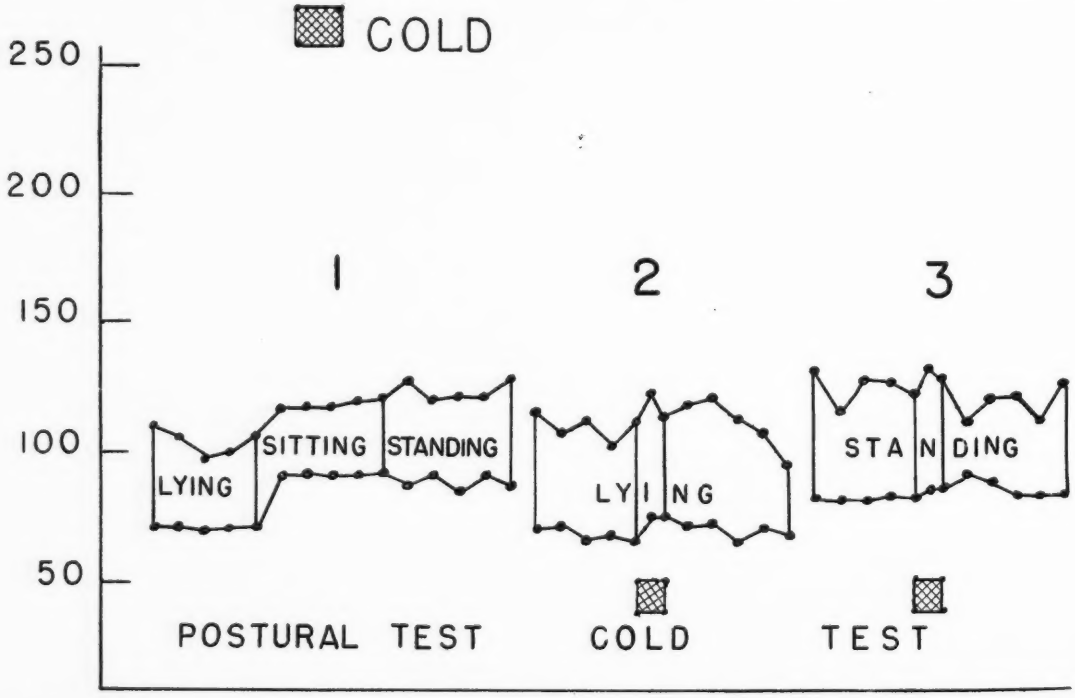

FIG. 317.—Postural and cold tests of a normal subject aged 50. On the left hand (1) are seen blood-pressure readings taken at minute intervals in the lying, sitting, and standing positions. The centre diagram (2) shows the lying cold test. Five pressures are taken lying. A hand is immersed in ice-cold water and a reading taken at 30 seconds after immersion. A second reading is taken 30 seconds later. The hand is removed from the water and 5 readings noted. The right-hand diagram (3) shows the standing cold test carried out as the previous one, except that the patient is standing.

Thus worth-while results assessed in terms of the blood-pressure were obtained by Smithwick (1944, b) in 87 per cent in Type 1, 77 per cent in Type 2, and 71 per cent in Type 3.

Average Resting Diastolic Pressure.—After two or more days' rest in bed a postural blood-pressure test is done, followed immediately by the Hines-Brown cold test. This is charted as in *Fig.* 317.

Smithwick's Groups.—This worker classifies his results in terms of the resting diastolic pressure into

five groups. The determination is made not less than one year after operation.

Group 1 *result*: A drop in the resting diastolic pressure of 30 mm. or more Hg (40 per cent).

Group 2 *result*: A drop in the resting diastolic pressure of 20–30 mm. Hg (20 per cent).

Group 3 *result*: A drop in the resting diastolic pressure of 10–20 mm. Hg (20 per cent).

Group 4 *result*: A drop in the resting diastolic pressure of 0–10 mm. Hg (10 per cent).

Group 5 *result*: The blood-pressure is higher after than before operation (10 per cent). Smithwick considers the first three groups to be significant. The approximate percentage results in each group are shown in brackets at the end of the line.

Just how stern a test of results this is may be seen from a consideration of the following case :—

Case B.P. 8.—Referred by Dr. Peacock.

A married woman, aged 49, who had suffered a good deal from retrosternal pain, cardiac asthma, and an oppressive bursting feeling in her chest. Grade 2 eyes. Electrocardiogram showed myocardial changes.

Sedation test 104/84.

Paternal grandfather died of a stroke and father died at the age of 40 of nephrosclerosis. Eighteen months after operation the patient reported freedom from symptoms and the eyes showed Grade 1 fundus changes. The pre-operative resting diastolic pressure was 132, the reading eighteen months after operation being 121, a fall of 11 points.

According to Smithwick's classification she is a group 3 result, only just falling within the worthwhile group. The graph of pre-operative postural and cold test with the eighteen months' check superimposed shows that, whereas the lying pressures indicate little betterment, the standing parts of the test show notable amelioration and much narrowing of the pulse pressure (*Fig.* 318).

Poppen and Lemmon (1947) practice an interesting method of assessing pre- and post-operative blood-pressure readings. The pressure taken on admission to the clinic or on the last visit before hospitalization is considered to be the pre-operative standard of comparison. Post-operative check-up is done by the family doctor or in the clinic, the patient being ambulatory. The reading is the post-operative one. The authors remark that the pre-operative pressure as taken above is often the maximal one. None the less the conditions are comparable before and after surgery.

Whilst admittedly less scientific and accurate than the Smithwick re-check, there is something to be said for this method as it saves an enormous amount of trouble and obviates the necessity of patients having to visit a clinic which may be attended with much expense and inconvenience. It has the added merit of bringing the house doctor into the team.

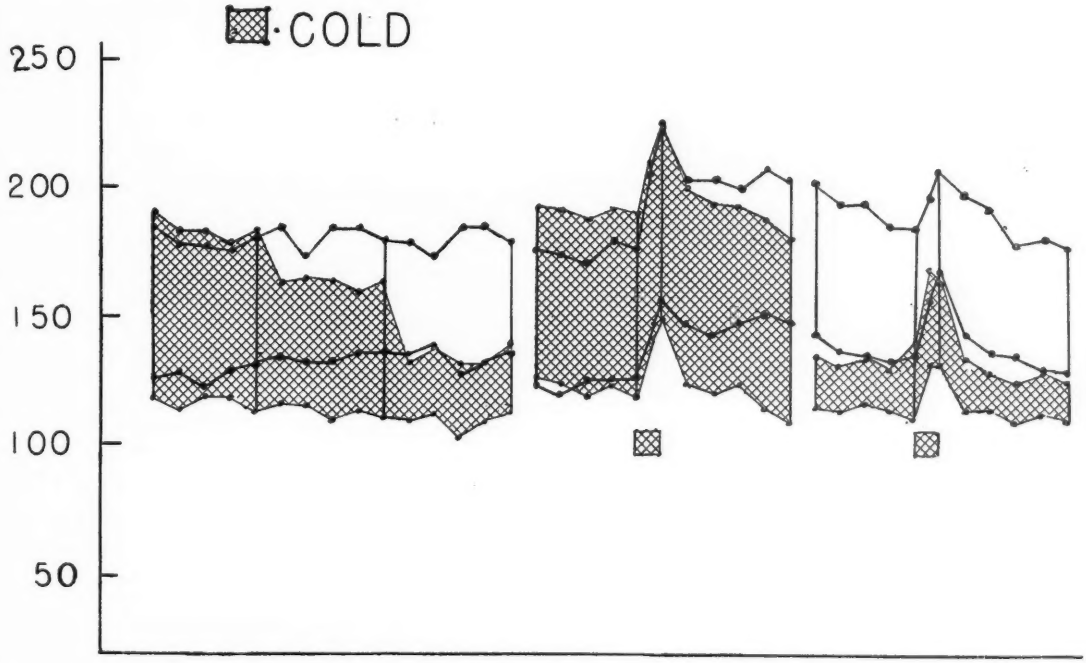

FIG. 318.—Superimposed graphs of *Case* B.P. 8. Pre-operative studies between black lines; readings taken 18 months after operation are cross-hatched. Note how in standing there is considerable improvement which is not brought out in assessing the result by comparing the pre- and post-operative resting diastolic pressures.

THE OPERATION OF LUMBODORSAL SPLANCHNICECTOMY

This is the Smithwick procedure. It is carried out in two stages, the one being done ten or more days after the other, no contra-indication existing. This description is essentially and basically that of the operation as the writer has seen it performed by its originator. Small departures from Smithwick's technique are such as have been gleaned from the work of others, e.g., James C. White (1946), or evolved with experience.

The patient is given penicillin just prior to and for three days after each stage.

The Method of Skin Preparation.—The back if hairy is shaved and washed with soap and water the night before operation. That is all. No dressings are applied and no antiseptics. On the table the part is painted with iodine. There have been two instances of mild wound sepsis in the 100 operations in the author's series presented. Neither was seriously ill. The method was observed first at the Massachusetts General Hospital, Boston, and has been used as a routine for all clean surgery since. There has been a notable absence of sepsis of any type.

Anæsthesia. — Positive-pressure intratracheal anæsthesia is of course essential as the pleura is sometimes opened. The induction is by pentothal and thereafter gas and oxygen and ether by intratracheal tube.

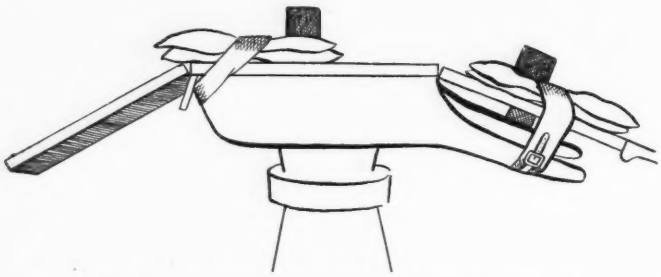

FIG. 319.—The operating table prepared for the patient. Note how the table is 'broken', the pillows in position, and the side pieces.

The Position on the Table.—The patient's position on the table determines the facility or otherwise with which the procedure is executed.

In the first case of this series the operation time for one side was four hours. The present time is under two hours. This is almost entirely due to a better understanding of position (*Fig.* 319).

The patient lies on the face with a firm but not a hard pillow under the upper thighs and another under the chest, leaving the abdomen quite unimpeded for breathing (*Fig.* 320).

The pillows are specially made not to project laterally and thus get in the way and are strapped in place. The table is then 'broken' in the middle or the leg end of the table is dropped and the back of the patient put on the horizontal by reverse Trendelenburg. The back should be straight, with no lumbar lordosis. Lordosis tenses the psoas, and as the lumbar sympathetic trunk is medial to the inner border of the psoas, it will be appreciated that a tense psoas makes the lumbar part of the operation difficult. The table can be tilted to the side, which is of great help when dealing with the neurectomy. The arms are extended in line with the body, giving the anæsthetist access to them for intravenous therapy and for recording blood-pressure. The pressure is taken and charted every fifteen minutes (*Fig.* 321).

Several cases with bad hearts gave concern, the pulse and even respiration disappearing. It was found that by side tilting the table to the patient's right or flat, thus easing the pressure on the pericardium, the patient's condition rapidly improved.

Dr. S. Hoffmann, who had given most of the anæsthetics, made the valuable suggestion that as the second operation imposes most strain, the right side should be done first so that, in tilting the table during the second stage, the patient's weight would be mainly on the right chest, thus easing the heart. This has become routine.

The Operation.—One assistant stands opposite the surgeon and one on his right. Intravenous 10 per cent glucose in water is set going at the beginning of the operation. Whole blood is given during the second stage.

The Incision.—An X-ray plate is before the surgeon to note the size and position of the 12th rib.

The ribs are palpated through a towel and the 11th rib followed medially. The incision commences about 4 in. above this point, that is at or above the level of the inferior angle of the scapula. It begins 2 in. from the midline, at the level of the

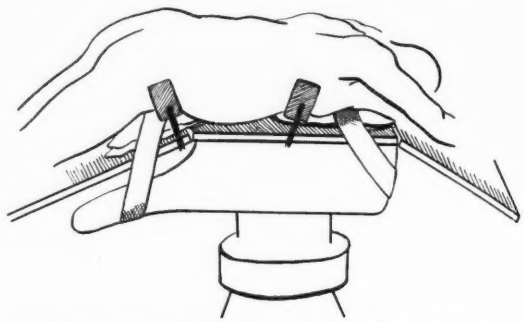

FIG. 320.—The patient in position for operation.

11th rib it is 3 in. from the midline, and then it swings gently outwards along the line of the 12th rib to just above the iliac crest (*Fig.* 322).

Mobilization of Sacrospinalis.—Skin towels are sewn to the skin after the manner of Smithwick.

The latissimus dorsi is cut through in the whole length of its exposure. The trapezius crosses the upper end of the wound obliquely and is not divided. Next the serratus posterior inferior shows its characteristic muscle and tendinous fibres and is cut through; so too is the thoracic part of the lumbodorsal fascia above and the posterior layer of

SECOND STAGE HYPERTENSION

Anæsthetic: Gas and oxygen with intratracheal intubation

Name: Mr. G——. *Age*: 47 years. June 3, 1947

TIME	PULSE RATE-	SYSTOLIC PRESSURE	DIASTOLIC PRESSURE	REMARKS
8.00	92	120	85	Intravenous saline
8.15	92	115	85	
8.30	92	110	80	
8.40	94	90	70	Blood transfusion
8.50	90	110	85	
9.00	90	100	80	
9.10	92	90	70	
9.20	96	80	60	
9.30	—	—	—	0·1 c.c. neosynephrin
9.40	96	130	100	
9.50	96	100	80	
10.00	—	—	—	

FIG. 321.—The anæsthetist's record.

lumbodorsal fascia below, allowing the tightly packed iliocostalis lumborum and longissimus to bulge laterally. The next step is the mobilization of the sacrospinalis. This is done with Mayo scissors, the tendinous slips of iliocostalis lumborum and dorsi being divided. The herring-bone muscular slips of longissimus dorsi and cervicis are similarly divided. There is little bleeding during this process providing care is taken during retraction not to tear the posterior branches of the intercostals which are passing directly backwards into the muscle mass. It is of moment to note that one of the posterior rami of the thoracic nerves runs with each of these leashes. They supply the transversus spinalis, the sacrospinalis, and skin. The inclusion of one of these nerves in a ligature is one of the causes of very troublesome neuritis following this operation.

Rib Removal.—The 12th rib is cleared laterally of muscles and its point freed, or if long, it is divided 6 in. from the midline. Here it is not related to pleura, so that a Doyen's raspatory may be pushed boldly anterior to the rib and its periosteum. The outer end of the section of rib to be removed is lifted with a meniscus or Lane's forceps and the intercostal muscles freed from its upper border, the

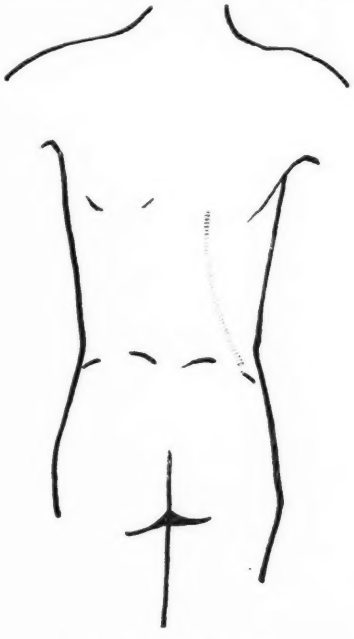

FIG. 322.—The incision.

pleura being pushed away with a guarding finger. The obliqui are cut loose from the lower border, keeping close to bone. This is the vascular area, the subcostal vein lying against the bone. So the detachment is continued medially, the lowest levator costæ muscle being divided above and the quadratus lumborum below. When the transverse process of the vertebra is reached the pleura is stripped well away and the rib is slowly bent back and may or may not fracture in the process. In any case it is retained as a valuable retractor to hold the sacrospinalis medially (James C. White, 1947).

Note that the ribs are removed with the periosteum to expose the pleura and allow of its being stripped from ribs and vertebræ.

The pleura is now gently stripped with the gloved fingers from vertebræ and ribs. Although sometimes removal of the 12th rib alone may be sufficient, it gives more room and allows of a wider neurectomy if part of the 11th rib is also removed. Here the removal is begun medially as the deep aspect of the inner end of the rib has been cleared of pleura. The upper margin of the rib is cleared with scissors

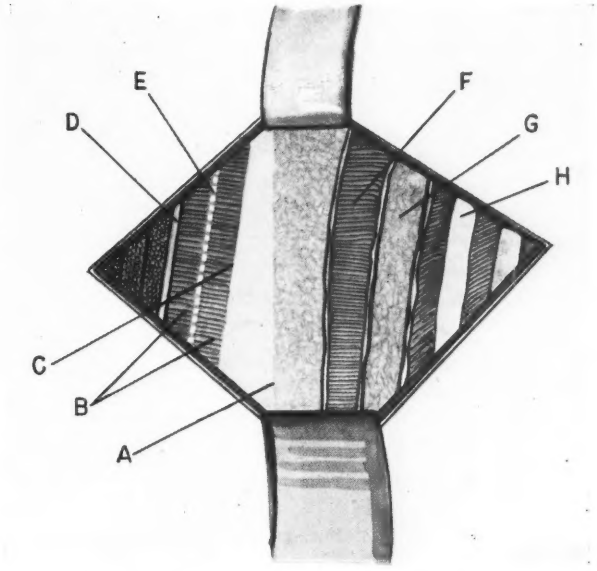

FIG. 323.—A diagrammatic representation showing the exposure after removal of the 11th and 12th ribs. The pleural reflection is seen, and the site of division of the diaphragm is shown by the interrupted line. A, Lower edge of lung; B, Diaphragm; C, Pleural reflection; D, Subcostal nerve; E, Line of division of diaphragm; F, Eleventh intercostal bundle; G, Site of removal of 11th rib; H, 10th rib.

of the curved Mayo type. The external and internal intercostals are divided plus levator costæ medial to the rib angle. The internal intercostal in relation to the inch of rib just lateral to the tubercle is a strong membranous structure separated by a little fat from the underlying pleura. Once this membrane is divided a finger may be pushed in to ensure that the pleura is out of danger. The lower border of this part of the rib is cleared of muscle, a Doyen rib raspatory pushed around the rib, which is cleared of further attachment over about an inch. The rib is divided at the tubercle with powerful shears. The outer divided end is gripped and in the same careful way the muscles are freed laterally, the pleura being pushed away. It is sufficient to remove 3 in. of this rib. It has been found unnecessary to nibble away the inner end of the rib and transverse process.

Division of the Diaphragm.—There is now exposed the subcostal nerve and vessels below, the diaphragm superior to this with pleural reflection crossing it transversely (*Fig.* 323).

Above this is the 11th intercostal bundle. This is not divided and not subjected to any rough retraction. The diaphragm is divided 1 cm. superior (cephalad) to the subcostal leash. To do this a nick is made through the lateral part of the muscle and the subjacent strong fascia transversalis is picked up and divided. Extraperitoneal fat bulges

through. A finger now slips readily under the diaphragm, which is divided with scissors over a length of about 6 in. Small bleeders are tied. Approaching the crus, the muscle is best dealt with by dividing it between Moynihan cholecystectomy forceps. At this stage the great splanchnic nerve is often seen penetrating the crus. It is interesting that quite often the outer part of the diaphragm is completely absent, only the fascia transversalis separating pleural and peritoneal cavities.

FIG. 324.—A, Slotted retractor; overall length 17 in. B, Pencil light (¼ size). (National opal glass Neico transilluminator.)

The Lumbar Part of the Neurectomy.—The kidney is now examined—some scarring may be seen, but rarely any gross pathology. The renal vessels are palpated for the Goldblatt phenomenon, and the suprarenal gland felt. If a tumour exists it is removed. Such tumours are not very rare, but the majority are small and not a factor in the hypertension. The kidney and fat are now stripped from the posterior abdominal wall and a roll of gauze is unwound and enough packed into the cavity to protect the kidney and fat. A broad retractor holds the tissues forward. A retractor of the Deaver type with a slot cut in it and a pencil light held in the slot with rubber bands, is now inserted (*Fig.* 324).

The psoas is held medially by the far assistant. The surgeon places the retractor, as the assistant cannot see the field. The table is now tilted away

FIG. 325.—The Smithwick hook; overall length, 12 in.

from the surgeon. The medial lumbocostal arch is seen arching over the psoas and musculotendinous fibres of the crus of the diaphragm are seen passing just medial to psoas to the lumbar vertebræ. It is in this angle that the lumbar sympathetic trunk lies. The psoas sheath is detached from the lumbocostal arch. The trunk lies out of sight actually medial to the inner border of psoas and on a posterior plane. It can usually be exposed here by retraction and careful dissection. Here the Smithwick hook is a valuable instrument (*Fig.* 325).

It is flat with a right-angled hook at one end. When the area is exposed and the surgeon is assured that no vessels are in danger, it is possible and helpful in difficult cases to hook up the lumbar trunk before it is visualized (*Fig.* 326).

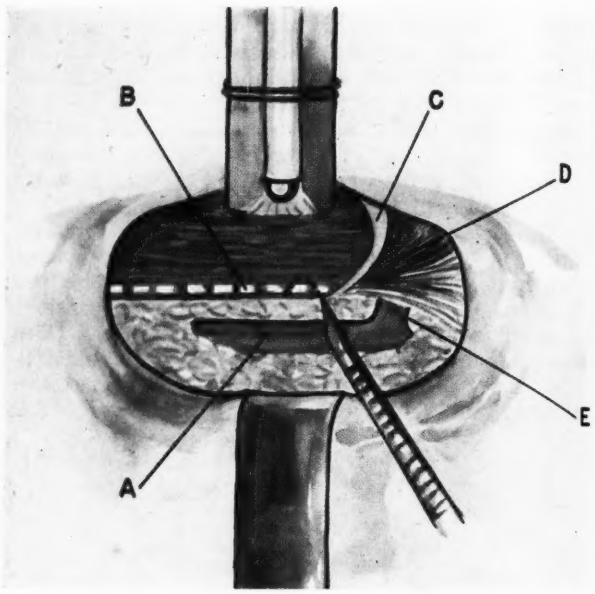

FIG. 326.—Semidiagrammatic view of the deep dissection in the lumbar region. The stippled line shows how, in many cases, the sympathetic trunk is tucked away under the edge of the psoas. The hook shows the 'blind pick up'. A, Vena cava; B, Lumbar sympathetic trunk; C, Medial lumbocostal arch; D, Diaphragm; E, Lumbar vein.

This is not an unsurgical procedure if the operator knows exactly what he is doing and is aware of the precise anatomy in the area. Not infrequently a surprisingly large lumbar vein is present here and deserves great respect. The trunk is then sought distally. It is usually possible to disentangle the mobilized nerve from the vein without damaging the latter. The lumbar trunk, having been raised on a hook, is dissected caudalwards, the large second lumbar ganglion being found near the lumbocostal arch. The trunk is clipped with a brain clip distal to the ganglion, gripped with an artery forceps, and cut with scissors. The ganglion is freed by snipping its connexions, each of which is first clipped. This procedure of Smithwick is an endeavour to prevent regeneration of the trunk. In the average case it is better to leave this part of the trunk at this stage and pick up the sympathetic again just above the diaphragm, where it is obvious as it trends down and in on the side of the vertebral body. Just above the diaphragm a constant long nerve is seen passing from without in to join the sympathetic. This is one of the lumbar rami communicantes passing down to the first lumbar ganglion and is 1–1½ in. long. The first lumbar ganglion is much smaller than the second, and fibres of the diaphragm must be cut through to expose it lying actually above rather than below the diaphragm. Below this ganglion there is an area ½ in. long where the trunk is very

firmly fixed by fibres of the muscle. When this part is freed the previously mobilized second ganglion is met and the first and second ganglia are loosened from all connexions. The part of the sympathetic trunk between first lumbar and 12th thoracic ganglia is usually very thin, like a piece of No. 2 catgut. One cannot but be struck by the size

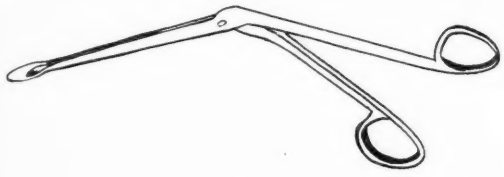

FIG. 327.—Hartmann's forceps; overall length, 9 in.

of the average lumbar trunk by contrast. The last two white rami—those to lumbar ganglia 1 and 2—thus bring large accessions from the cord.

The Thoracic Neurectomy.—The pleura is now carefully stripped in an upward and inward direction and the freed lower end of the sympathetic is held by an artery forceps whilst the trunk is mobilized upwards. Each ganglion is carefully dissected from fat and the subjacent neurovascular bundle, great care being taken to clip each strand of nerve before division. It is disconcerting to cut an intercostal artery at the bottom of a small deep cavity, and an intercostal artery with its accompanying vein lies in

FIG. 328.—Retractor with slot for pencil light for insertion into the narrow cavity between ribs and pleura in the thoracic portion of the dissection. Overall length, 18 in.

contact with each ganglion. On rare occasions the vessels may pass anterior to the ganglion. An essential and valuable ally in this dissection is Hartmann's forceps (*Fig.* 327).

As the dissection proceeds cephalad the pleura is stripped. The best way to do this is with two fingers, not to use swabs, and not to strip laterally where it readily tears. This is of no very great significance providing the anæsthetist can inflate the lung. A small hole in the pleura is a nuisance, as air is sucked in and the pleura balloons out obstructing the field. Should this happen the opening in the pleura should be snipped with scissors to a size greater than the glottis, when it will collapse. As the dissection proceeds upwards, the lower end of the trunk is gripped above the 11th intercostal bundle and a special lighted retractor introduced anterior to the ribs (*Fig.* 328).

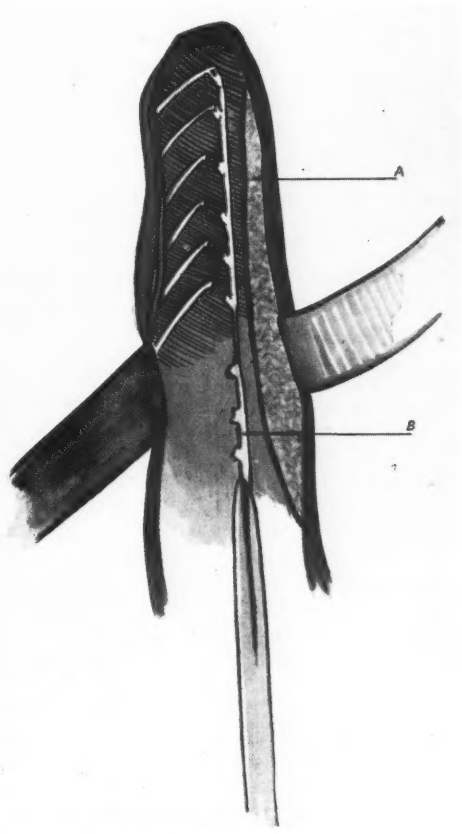

FIG. 329.—Semi-diagrammatic view of the upper part of the dissection.

Excellent lighting is obtained. The ganglia are freed to at least the 9th thoracic and to include the 8th and even the 7th if possible. The trunk is then clipped as high as possible and the ganglionated cord removed. It is now apparent why the mobilization of the sacrospinalis is carried so high, to give adequate exposure in this deep dissection (*Fig.* 329).

Splanchnicectomy.—The operation is now shifted to immediately above the diaphragm where the great splanchnic nerve is easily found lying on the vertebral bodies. It is clipped just where it pierces the diaphragm and cut. The free end is clipped with artery forceps and with a finger the nerve is rapidly stripped as high as possible—i.e., even above the level of the sympathetic section. It is then clipped and cut or avulsed between two gall-bladder forceps. Finger stripping is better than dissection, which may tear the pleura which is the anterior relation to the nerve. A search is made for the lesser and lowest splanchnics and these are removed.

The neurectomy is now complete.

Biopsies.—The kidney is freed of fat posteriorly, the fat at the upper pole gripped with an artery forceps to steady the organ, and two sutures passed through the kidney ¾ in. apart with an atraumatic needle and 0000 catgut (*Fig.* 330). With a sharp

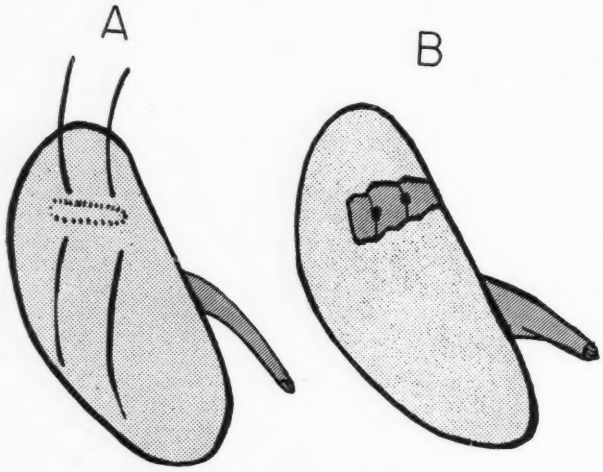

FIG. 330.—Method of taking the renal biopsy. A, Sutures inserted and portion of tissue to be removed indicated. B, Sutures tied over fat.

knife a piece of kidney ¾ in. long and ¼ in. broad and the same thickness is removed. It is not touched with forceps, but lifted on the knife into a bottle of formol saline. A strip of fat is put across the bleeding wound and the two sutures tied over it. This stops the ooze. A piece of sacrospinalis 2 × ¼ × ¼ in. is then removed as a muscle biopsy and put in the preservative.

Closure.—The 12th rib, if it has been retained as a retractor, is now removed. If, as often happens, it is not fractured and its costovertebral attachments are firm, the rib may be left in situ. The diaphragm is approximated with a few silk sutures, great care being exercised not to include the subcostal nerve in a suture. A rubber catheter as thick as a lead pencil is now put into the chest cavity or pleural cavity—if this has been opened—and another to the back of the kidney. No attempt is made to close any pleural opening. The anæsthetist inflates the lung and the wound is not closed until it is seen that the lung is fully inflated. The sacrospinalis is drawn across the rib gap with a few interrupted sutures. The obliqui and latissimus muscles are now approximated with interrupted cotton sutures. The skin towels are removed and the skin closed with interrupted cotton sutures. Suction is applied to the catheters, which are slowly removed as the anæsthetist maintains inflation of the lung. A strip of gauze is fixed on the wound with mastisol and adhesive plaster.

Removal to the Ward.—The anæsthetist superintends the removal of the patient to the trolley. The procedure is carried out very slowly. One patient died after the completion of the second stage operation whilst being moved on to the stretcher. Mediastinal shift may follow a too rapid transfer. The same care is exercised on putting the patient to bed.

Post-operative Treatment.—A specially trained staff is necessary in the post-operative period. Blood-pressure often drops alarmingly, e.g., 50/20 mm. Hg. The patient is in the Trendelenburg position in bed and the blood-pressure recorded each 15 minutes. Should the systolic drop to below 80 neosynephrin, 0·2 c.c., is injected, each fifteen minutes if necessary. If the pressure does not rise to 90 mm. Hg in two hours, a blood transfusion is given. The staff is trained to bandage lower limbs and abdomen if necessary. When pressures are satisfactory and the patient conscious, he lies on a few pillows, being changed on to back or unoperated side each two hours. Analgesics are exhibited as indicated. Penicillin is continued for three days. Recovery is remarkably speedy and uneventful. The patient sits on the edge of the bed dangling his legs on the third day and gets up on the fourth or fifth day with legs bandages on and a corset or two-way stretch to prevent postural hypotension. On standing erect there is often a tendency to faint as blood rushes to the denervated splanchnic and sural lakes. The patient finds more comfort if he moves around than if he stands still. The hospital stay is four or five weeks. The patient returns a month after discharge. The blood-pressure is taken erect with one leg bandage off. If there is no appreciable fall in pressure the bandage is left off. At the end of another month the same test is carried out in regard to the remaining bandage. A month after this the abdominal support can usually be discarded.

Extension of the Operation for Hypertension.*—During a visit to Professor Smithwick's clinic earlier in the year the writer was privileged to see the Professor perform total thoracic sympathectomy and splanchnicectomy. The indication for this procedure is severe cardiac pain (angina) from coronary damage in association with essential hypertension. As the heart is supplied with sensory nerves via the upper four intercostal nerves through the upper four thoracic ganglia and the splanchnic bed is supplied with vasoconstrictor nerves from the 5th to the 12th intercostal nerves via the lateral ganglionated chain and the splanchnic nerves, it is apparent that total thoracic sympathectomy plus splanchnicectomy will produce maximal denervation of the splanchnic area and denervate the heart.

The patient is on his side, the 6th rib is removed subperiosteally from the costochondral junction almost to the angle, and the exposure improved by dividing the 5th rib anteriorly and the 7th posteriorly and using a rib spreader. The operation is transpleural, and part of the stellate, the whole thoracic sympathetic chain, and the splanchnic nerves are removed in one bundle. The lung is held medially by retractors.

This operation is a more severe one than the usual Smithwick lumbodorsal splanchnicectomy. The mortality is therefore higher. A serious feature is that it is followed by a much more severe neuritis than the usual retropleural procedure. No explanation is forthcoming to account for this pain, as it does not follow thoracotomies for other procedures.

* These are the views gathered, the writer believes accurately, from personal communication with Professor Smithwick.

Smithwick considers it inadvisable to include the upper two lumbar ganglia in this neurectomy and advises a separate set operation if this procedure is considered advisable.

These operations must of course be bilateral.

In cases of persistent tachycardia following splanchnicectomy the condition can be cured by cardiac denervation. This can be adequately performed from the back by removing an inch of each of the 2nd and 4th ribs just lateral to the tips of the transverse processes and resecting the upper four thoracic ganglia.

SERIES OF FIFTY PERSONAL CASES

It cannot be too strongly emphasized that the investigation, surgery, and nursing of hypertensive cases requires a team. If operation is undertaken without proper study and understanding, then results will be bad.

The wisdom of those responsible for devising these operations and laying down rules and criteria may be estimated by the extraordinary low mortality in large series of cases. It is probably correct to say that in the whole range of major surgery there is no procedure which carries a comparably low mortality. The small series reported here represents the first 50 private cases of the writer.

The first case was done about 28 months ago and the others more recently. They have all been treated in the same nursing home and the blood-pressure and other tests carried out by the same staff and the surgery by the same team. Most of the anæsthetics have been given by the same anæsthetist, Dr. S. Hoffmann.

It is too early to give any final conclusions and too few cases have been done for one or more years to make a detailed analysis of results worth while. Some facts and representative cases are presented and from these certain conclusions may be drawn.

These 50 cases represent about 30 per cent of those referred for study. Most of the balance were told that operation was not indicated because of lack of symptoms and/or organic damage due to hypertension. They were advised to report annually for re-check so that advice could be given as indicated by successive studies and careful observation. Operation was refused in 8·5 per cent because the tests showed that operation held out but small prospect of relief. Three cases which had entered the accelerated phase of the disease (malignant hypertension) with Grade 4 eyes and severe kidney damage were refused operation and died in a few weeks.

One patient, whose test being completed, wished to go home for the week-end prior to operation, was found dead in her bath, the cause of death being apoplexy.

There were 29 women and 21 men. The average age of the group was 40·12 years, the youngest being 31 and the oldest 56.

There were two deaths in the series, making a 2 per cent operative and a 4 per cent case mortality. Both were due to heart failure, one on being moved from the table; the second two days after operation.

Complications.—Complications of any kind are rare.

Wound sepsis—2 cases.

Burst wound—2 cases, in which a small gape required suture.

Extrapleural or pleural hæmatoma—8 cases—one aspiration was sufficient in each case. This is done about the tenth post-operative day.

Intercostal or lumbar nerve neuritis: Many cases have some referred pain consequent on unavoidable retraction. This soon clears up and responds to mild analgesic drugs. There have been 3 cases of quite severe neuritis. It is possible that in these cases a nerve may have been caught up in a suture. All cleared up eventually. Smithwick* deprecates deliberate cutting of the 11th intercostal nerve, stating that the procedure, so far from preventing, is likely to produce nerve pain.

Cerebral thrombosis—3 cases: These are worth some detail. When it is remembered how low the blood-pressure drops after operation it is remarkable that the complication does not occur oftener. All 3 cases were women. In one a hemiplegia occurred, in another motor aphasia, and in the third a mild upper neurone facial palsy. The signs appeared some hours after operation and developed slowly. In all a good prognosis was given. The hemiplegia took a week to recover, the aphasia four days, and the facial palsy three days.

Lung Complications.—It is a remarkable tribute to modern anæsthesia that not a single lung complication occurred in these 100 extensive operations. One of the cases which died developed a capillary bronchitis which was however a terminal event. A factor of importance is the prophylactic chemotherapy exhibited for three days. This was originally sulphadiazine and is now penicillin.

Renal Biopsy.—Castleman and Smithwick (1943) classified the renal arteriolar changes in continued hypertension. They divide them into 5 grades—0 to 4.

Grade 0—No change.
Grade 1—Minimal change.
Grade 2—Mild change.
Grade 3—Moderate change.
Grade 4—Severe change.

It is of the greatest significance to be able to correlate renal histological data with the clinical picture. It is also a valuable check on the accuracy of the diagnosis and the degree of accuracy in the selection in cases for operation.

As Smithwick (1947) pointed out, the percentages of successes and failures are much the same in cases with biopsy 0—2 as in those with grade 3—4 histology. In 45 of these 50 cases biopsy results were as follows:—

Grade 0—12.
Grade 1—22.
Grade 2— 9.
Grade 3— 2.
Grade 4— 0.

It was not possible from the clinical study to forecast the biopsy grading.

Effect of Operation One to Two Years later.—It is correct to say of the 48 survivors of the

* Personal communication.

two-stage operation that there is not one of the group who has not benefited in some way—by fall in pressures, relief of symptoms, ability for more sustained effort, or improvement in damaged organs. The effect of operation on vasospastic pathology of the eye grounds is remarkable, and there are a number of such cases even of Grade 4 severity (papillœdema) who showed normal fundi at the first re-check.

The same may be said of electrocardiographic findings, return to normal in the size of the heart, etc. The reversibility by operation of damage produced by hypertensive disease is well known, and this improvement is abundantly manifested even in the groups 4 and 5 results where the fall in blood-pressure is considered not worth while. Roughly half of the cases in these groups show eye-ground, electrocardiographic, and renal betterment.

It cannot be stressed too emphatically that the criterion of lowering of the resting diastolic pressure as a measure of the success or otherwise of the Smithwick operation, is the sternest possible test. As pointed out above some of the most dramatic results have occurred in cases where the fall in the resting diastolic pressure has been negligible or small. People who have been almost bedridden or who have relinquished or given up their avocations have regained good health, resumed their normal occupations, and become contented happy people with a new lease of life. These are imponderable factors and often only heard of indirectly through relations or friends of the patient. Whether it is an 'internal venesection' or due to some other unknown cause, this physical and mental betterment is one of the most remarkable of the results of splanchnicectomy and cannot be disregarded in assessing the value of surgery in hypertension. Several case histories will now be submitted.

The first, one of the earliest in the series, is that of the only case in the group where the pressures a year after operation were higher than those prior to operation. Reviewing the case, it is apparent that operation would be refused to-day in a comparable case.

Case B.P. 9.—A young married woman, aged 33, referred by Drs. Byala and Bayer, complaining of great fatigue, palpitations of the heart, and a constant feeling of tension. Father died from hypertension at an early age. Electrocardiogram showed early coronary changes and left ventricular preponderance. The renal function was poor, blood-urea was 46 mg. per cent, and phenol-sulphonephthalein excretion was borderline. Sedation poor: 138/102.

The graph shows a Group 5 result (*Fig.* 331).

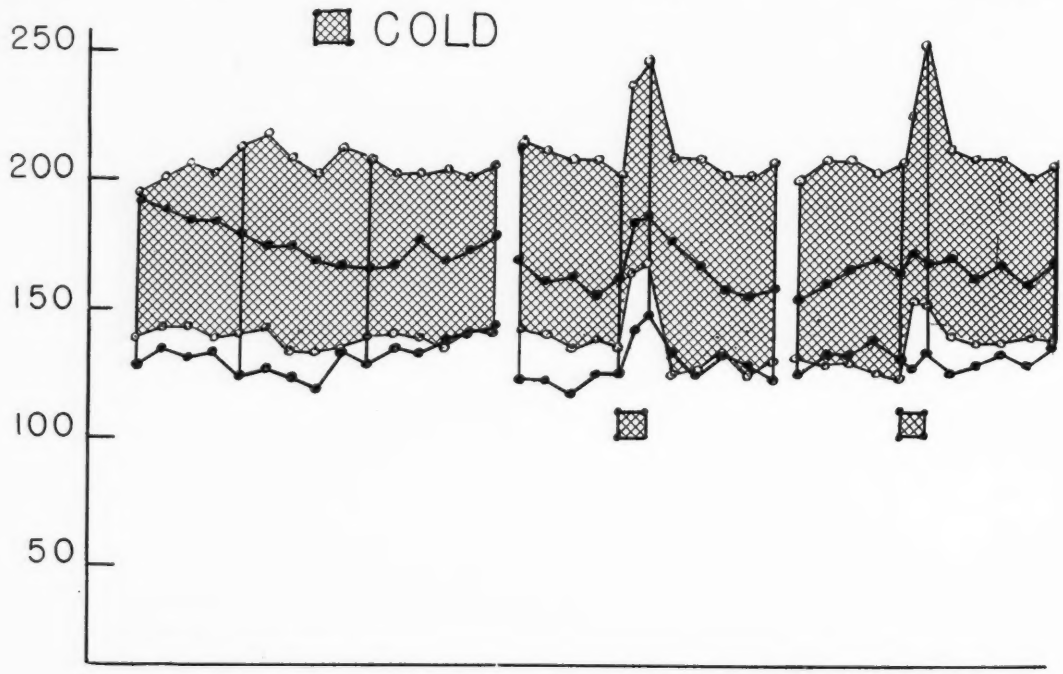

FIG. 331.—*Case* B.P. 9. Pre-operative study between black lines; 1 year post-operative, cross-hatched.

This case was one in which the renal damage was so great that little was to be expected from operation. The patient has, however, lost her headaches, regained her confidence, and feels a good deal better than before.

Case B.P. 36.—A young married woman, aged 36, referred by Dr. Alexander Bell, engaged with her husband in conducting a popular and busy hotel.

She has constant headaches and giddiness. Suffers from palpitations and bad temper. Is always lazy.

Pre-operative study showed no gross abnormality, eyes showed no fundus changes, heart and kidney function good. The average resting pressure was 184/120, bringing her into Type 2.

The sedation result was indifferent: 128/100.

The graph shows a Group 2 result (*Fig.* 332).

	Before operation	1 *year after operation*
Average lying pressure	184/120	126/96
Average standing pressure	193/140	124/86
Type	2	1

A year after operation she was on full duty, free of symptoms, and had regained her normal equable temper. Two years after she maintains her well-being although

The graph shows a Group 2 result. One year after operation the patient is free of all symptoms and back at full work.

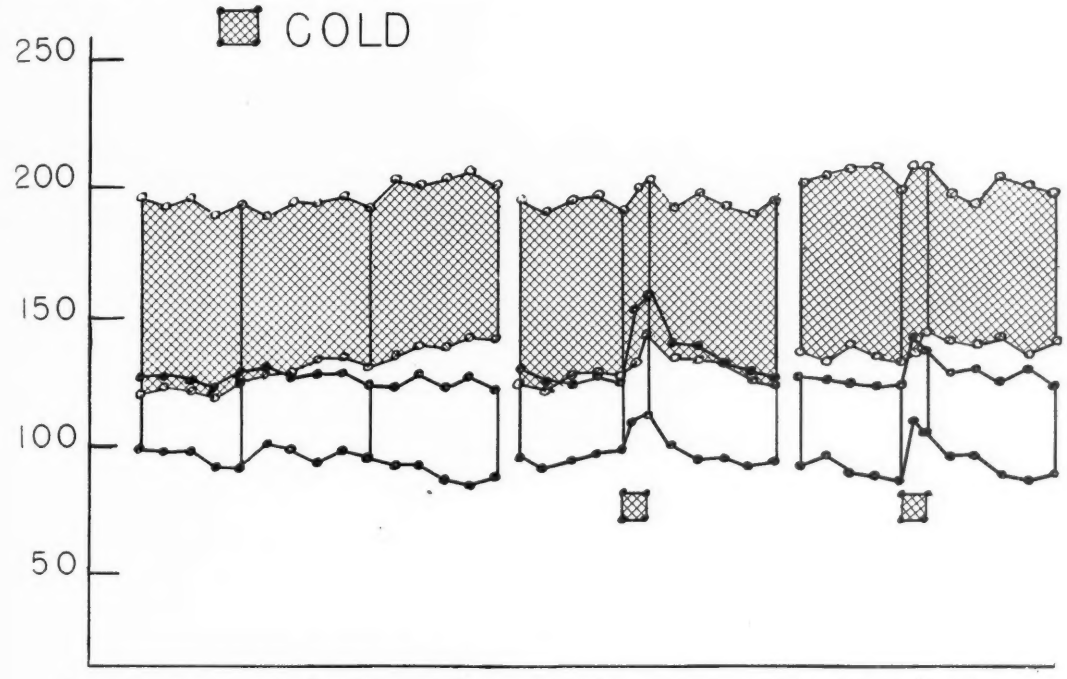

FIG. 332.—*Case* B.P. 36. Pre-operative studies cross-hatched; 1 year post-operative, between black lines.

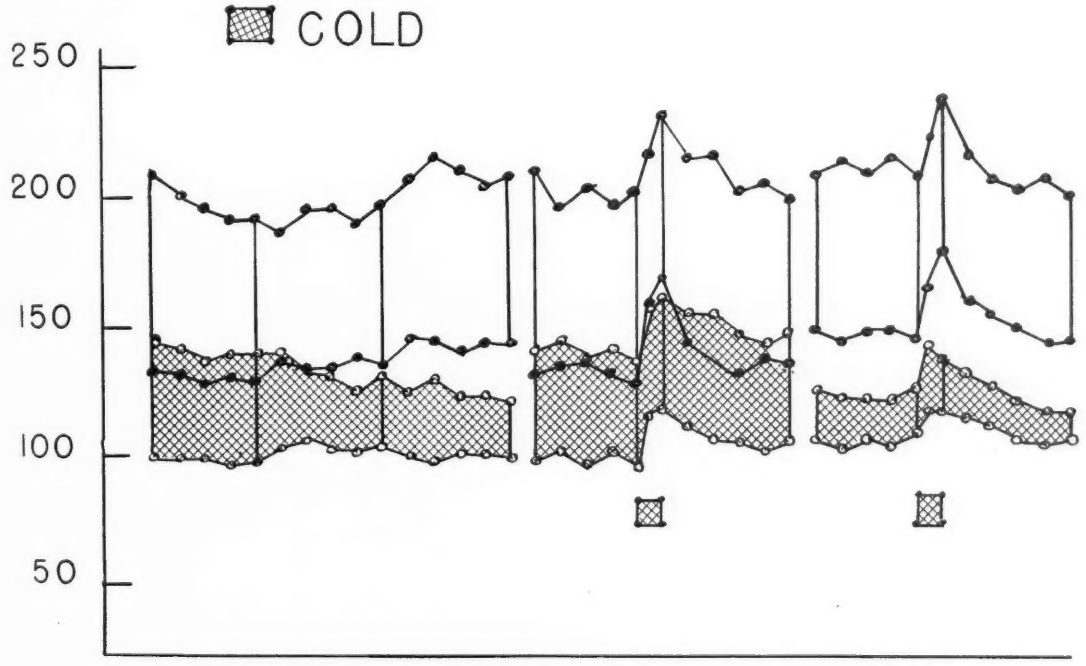

FIG. 333.—*Case* B.P. 95. Pre-operative between black lines; Post-operative, cross-hatched.

no opportunity has offered for the second annual blood-pressure re-check.

Case B.P. 95.—Army captain, aged 43, referred by Col. Agranat. He complained of tightness across the head and had had several blackouts.

Eyes Grade 1. Some cardiac enlargement and changes in the electrocardiogram. The condition was progressing. Sedation 152/110 (*Fig.* 333).

	Before operation	1 *year after operation*
Average lying pressure	196/120	139/97
Average standing pressure	207/141	122/96
Type	2	1

Case B.P. 97.—Trained hospital nurse referred by Dr. McKenzie. Aged 32, married, two children.

The blood-pressure was normal four and a half years ago and is now mounting quickly. Eyes Grade 1. There are electrocardiographic changes of some severity. Renal function good. Mother died of stroke at the age of 36. Father died of high blood-pressure aged 59.

The graph shows a Group 1 result (*Fig.* 334). The patient returned to work two months after the second-stage operation. She has been working ever since, and is in normal health; both electrocardiogram and eye grounds are now normal.

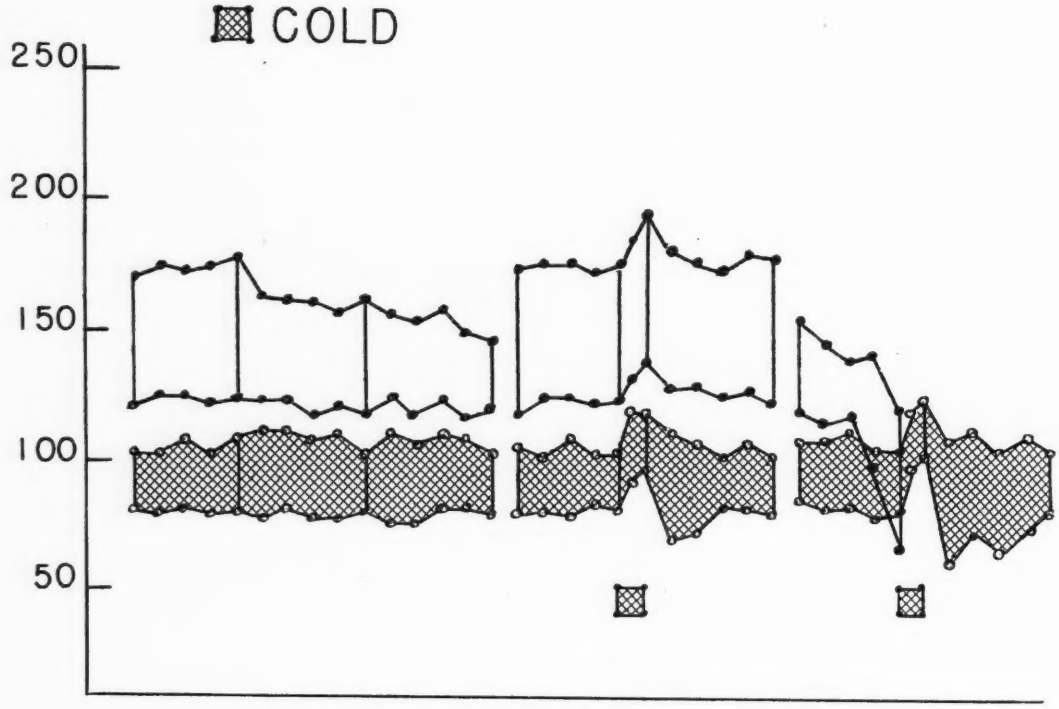

FIG. 334.—*Case* B.P. 97. Pre-operative between black lines Post-operative cross-hatched.

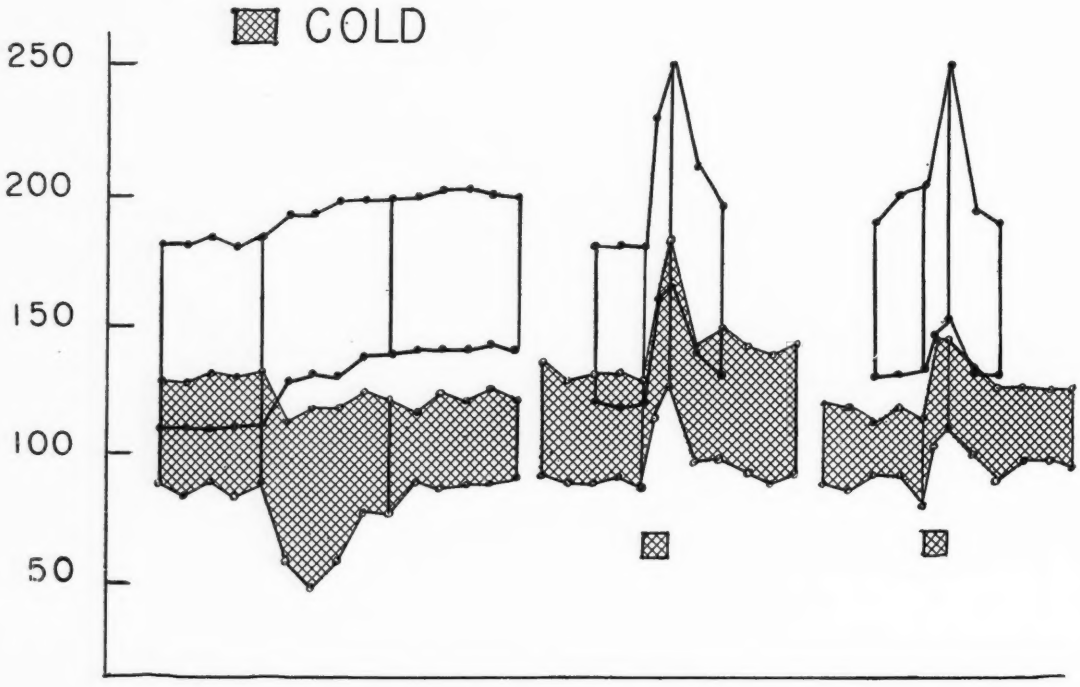

FIG. 335.—*Case* B.P. 26. Pre-operative between black lines; 2 years post-operative, cross-hatched.

Before operation		1 *year after operation*
Average lying pressure	173/124	106/81
Average standing pressure	153/121	109/78
Type	I	I

Case B.P. 26.—Referred by Dr. Fasser and Professor Kloppers. A garage proprietor, aged 46, who began to suffer from headaches two years ago. These are becoming worse. Eyesight and hearing are deteriorating and so is his handwriting. He stumbles in walking, and is in a constant restless state. His mother died of high blood-pressure at the age of 20. Eye grounds showed hæmorrhages—Grade 3. The heart and kidney functions were normal. The sedation test was 120/90.

The graph at the check-up two years after operation shows a Group 1 result (*Fig.* 335). The eye grounds are normal. The patient has been at full work since two months following operation and has been symptom-free.

SUMMARY

1. The surgery of hypertension has become a successful therapeutic field largely owing to its development by the enterprise of American surgeons.

2. The mortality of operation is lower than in any field of comparable magnitude.

3. To attain this enviable standard requires meticulous study, wise selection, and well-trained teams.

4. The results of operation are remarkable, 80 per cent of patients achieving a worth-while fall in the resting diastolic pressure, and 90 per cent obtaining relief of symptoms.

5. The damage done to eye grounds, myocardium, and kidneys is reversible by operation in a notable percentage of cases.

6. These eminently satisfactory results are for the most part sustained in follow-ups for periods as long as eleven years.

7. Conservative measures have nothing comparable to show, but are none the less useful adjuncts to treatment.

8. Medical and surgical forms should be considered, not as mutually antagonistic, but as complementary measures of treatment.

The development of this work has been rendered possible by the enthusiastic help of ex-housemen of the author, notably Drs. Bradlow and Leiman. Matron Miller and her staff at the Lady Dudley Nursing Home have done their work so well that there have been no worries after operation.

Dr. S. Hoffmann has given most of the anæsthetics and the skill and courage he has shown have been altogether beyond praise.

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PERSISTENT PRIAPISM*

By HAMILTON BAILEY

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On Saturday night, March 8, 1824, A. B., aged 44, came home inebriated, and had three connexions with his wife without producing collapse of the penis. On Sunday, Monday, and Tuesday the organ remained erect. On Wednesday Thomas Callaway, Surgeon to the South London Dispensary, was called in. He noted that the corpora cavernosa were turgid, the corpus spongiosum was not turgid, and the glans penis was soft and yielding. Twelve leeches, cold lotions and other applications, nauseating doses of tartar emetic, tobacco enemata, mercurial inunctions, and the whole range of narcotics were prescribed, without the slightest benefit. On the sixteenth day Callaway took a lancet and incised the left crus below the scrotum. Dark grumous blood with clots escaped. The penis was squeezed and the organ collapsed. The patient made a good recovery, but remained impotent.

It is doubtful if the average sufferer from spontaneous persistent priapism would receive to-day much better diagnosis and treatment than A. B. received in those far-off days at the hands of Mr. Callaway. Probably the consultant would mention leukæmia and endeavour to palpate the spleen for enlargement. The narcotics prescribed would be more elegant, and the local applications might include an ethyl chloride spray. Even after the patient had been admitted to hospital, it is more than likely, while attracting considerable clinical interest, after either receiving no active treatment, or after the administration of a spinal anæsthetic and ineffective aspiration of the corpora cavernosa, he would discharge himself from hospital. The last event has figured largely in my experience of these cases, and it is in keeping with many case reports in the literature.

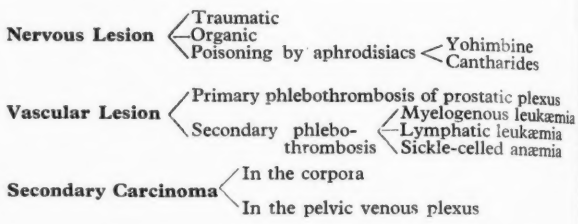
Amazingly, a proportion of the patients who return home, recover. Eventually the priapism undergoes gradual spontaneous detergescence. For instance :—

On April 12, 1844, a sailor, aged 25, in perfect health, arrived from Calcutta and lodged with a female in London. On the fourteenth night he experienced an intense erection with pain. Though coitus was frequent, the symptoms continued, and on the following day he was admitted into the London Hospital, where he received various remedies. At the end of a month his leave expired, and he boarded his ship with the penis at an acute angle with the pubis. On return to England the organ was flaccid, and his symptoms had disappeared. The erection, he affirmed, lasted in all three months. (Tripe, 1845.)

It can be said that very few patients who recover from persistent priapism regain their pristine potency.

AETIOLOGY

The causes of priapism may conveniently be dealt with under the following headings.



At this juncture let us dispose of priapism due to secondary carcinoma. The deposit causing obstruction to the venous return of the penis is lodged either in the corpora cavernosa (*Fig.* 336) or, more usually,

FIG. 336.—A deposit of secondary carcinoma in the base of the corpora cavernosa that caused priapism. (L. G. Craig's case.)

within the pelvis. An analysis of 20 cases showed that the primary growth was situated as follows.—

Bladder	6	Kidney	3
Rectum	5	Testicle	2
Prostate	3	Urethra	1

Priapism due to Nervous Causes.—From time immemorial it has been known that those hanged by the neck develop priapism. There are, however, very few first-hand scientific records of the phenomenon. No doubt this omission is due to the fact that most members of our profession who

* Read at the Annual Meeting of the British Association of Urological Surgeons at Glasgow on June 14, 1947.

have had to be present at executions, by reason of the very fundamentals of their calling, would rather look the other way. Marcel Guyon, Surgeon-Major to the French Army, has left us a sufficient record. In 1823, on the island of Martinique, he observed in one day 14 executions by hanging. At the moment of strangulation the penis became suddenly and forcibly erect; in all cases, one hour after death it was still half erect.

It is well known that lesions of the spinal cord, particularly traumatic lesions, and notably those associated with fracture-dislocation of a cervical vertebra, are occasionally complicated by priapism. In my small experience I have noted (1) the erection is of the three-quarters variety, (2) it does not appear to be painful, and (3) the patient develops retention of urine. I suggest that the retention is not due to the priapism, but to interference with the nervous mechanism controlling micturition.

There is very little to be found in the literature on priapism due to *disease* of the central nervous system. As might be expected, syphilis plays a part in this rare manifestation of spinal cord dysfunction, but multiple sclerosis is cited in the neurological literature as the most common spinal cord lesion giving rise to priapism (Wilgus and Fell, 1931). Hinman's classical study (1914) is much quoted. Of 35 cases of priapism due to central nervous disorders, 5 were associated with nasal polypi; removal of the polypi was followed by a cure. Unfortunately, I am not in a position to attempt to explain this remarkable phenomenon.

Regarding priapism due to excessive doses of aphrodisiacs, yohimbine produces the only form of priapism where the corpus spongiosum is more involved than the corpora cavernosa (Creecy, 1934). That the priapism, originally nervous in origin, can pass on to priapism due to thrombosis is proved by a case where the erection persisted after death (Scheidegger, 1932).

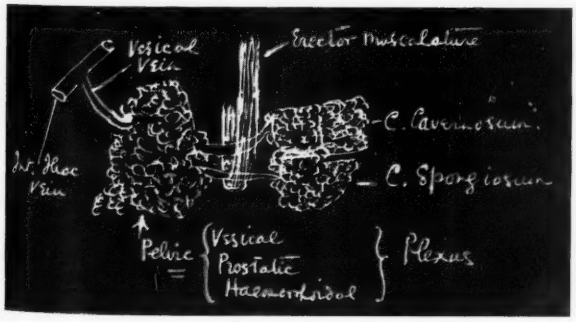


FIG. 337.—Clotting in the formed veins behind the erector musculature is most probably the initial cause of vascular persistent priapism. (Blackboard sketch.)

Priapism due to Vascular Causes.—This is the largest and most important group. The erection is maintained, not by contraction of the erector muscles obstructing the venous return by pressure from without, but by clotting within. There is every reason to believe that clotting commences behind the erector muscles in the formed veins that connect the venous honeycomb of the phallus with the largest and most complicated venous network in the body—the pelvic plexus (*Fig.* 337), which can be subdivided into the prostatic, vesical, and hæmorrhoidal plexuses.

The most convincing post-mortem evidence supporting this hypothesis is to be found in the following case report:—

A young officer was wounded in the pelvis. Persistent painful priapism developed soon afterwards and continued for ten days, when gangrene of the organ set in and he died. A lesion of the spinal cord was suspected,

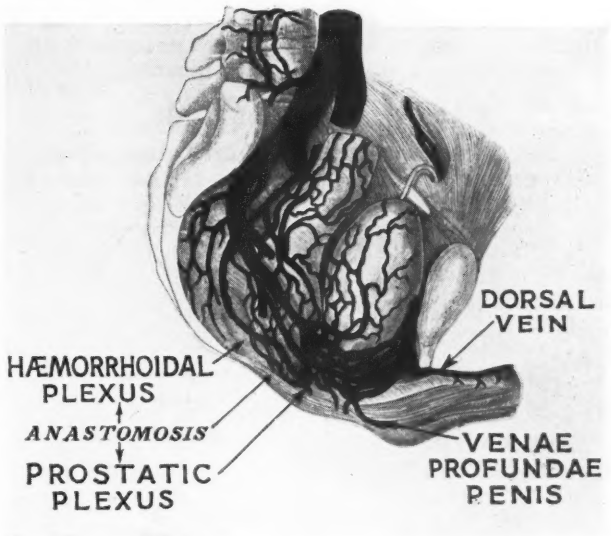


FIG. 338.—The pelvic venous plexus, showing its connexions.

but at necropsy the cause of the priapism was shown to be thrombophlebitis of the deep pelvic veins. A piece of cloth had been carried into the depths of the wound. (Basil Hughes, 1932.)

There are other post-mortem records of thrombosis of the deep pelvic veins in cases of persistent priapism.

That thrombosis of the deep dorsal veins which drain into the prostatic plexus is the most usual cause of vascular priapism is substantiated by the well-established clinical observation that in 5 out of 6 cases the corpora cavernosa alone are involved. When the corpus spongiosum and the glans penis share in the erection, the thrombosis is presumably more widespread; it involves the venæ profundæ, which drain the bulb of the corpus spongiosum and open into that part of the pelvic venous plexus in free communication with the middle hæmorrhoidal vein (*Fig.* 338).

The next problem that requires elucidation is to account for the clotting. Quite rightly, the existence of leukæmia or sickle-celled anæmia should receive primary consideration. At the same time it is most desirable to realize that these blood diseases are present in not more than 15 or 20 per cent of cases.

Trauma can cause thrombosis. In a few reported cases there seems no doubt that the priapism followed an accident such as a fall astride. It is possible that fewer still are the result of a mishap during coitus. It is, however, certain that trauma plays an extremely small part in the production of pelvic thrombosis.

Hyperpiesis is stated by Morson (1934) to be a frequent cause of the phlebothrombosis resulting in priapism. From a study of reported cases I can find no justification for this statement; indeed, in the majority of cases the cause of the thrombosis remains unproven.

Focal sepsis is a leading cause of thrombophlebitis. No shadow of doubt exists regarding the association of thrombosis of the circulocavernous sinus and infection of the upper lip. With the veins of the urethra, the prostate, the bladder, and the anal canal pouring their blood into the pelvic plexus, there is reason to wonder why thrombosis of this plexus occurs so infrequently in the male.

CLINICAL FEATURES

The penis is usually maintained at an acute angle with the pubis (*Fig.* 339). It is obvious that the

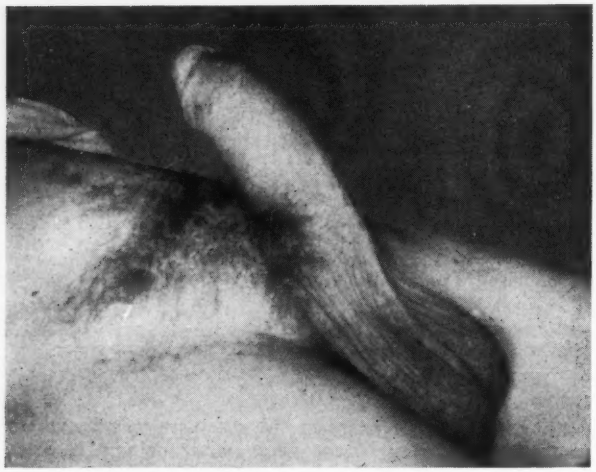


FIG. 339.—Persistent priapism in a man of 56. Condition on the fifth day.

pain is variable, for no man could endure weeks or months of agony in the manner in which many await the advent of detergescence. In some instances the pain is so great that heavy doses of narcotics are required for many days. The pain was so severe and so much morphine and other drugs had been given that one of my patients was rendered not fully *compos mentis*. Palpation of the glans penis between the finger and thumb, followed by the passage of a finger along the floor of the urethra, usually reveals softness, as compared with solid induration of the corpora cavernosa; indeed, in about 90 per cent of cases the corpus spongiosum is not involved (Defesche, 1939). The non-involvement of the corpus spongiosum accounts for the infrequency of dysuria or retention of urine accompanying priapism.

Judged by reported cases, coloured men who dwell in Southern States of America are particularly prone to the condition.

The age of the patient in 34 consecutive case reports I have studied shows that the condition may occur at any time of life (*Fig.* 340). Very young patients are usually, but not invariably, sufferers from leukæmia or sickle-celled anæmia. As would be expected, the elderly group includes most of those where a deposit of neoplastic cells is the cause of the priapism, but again, even during the seventh decade, priapism is not necessarily due to malignant disease.

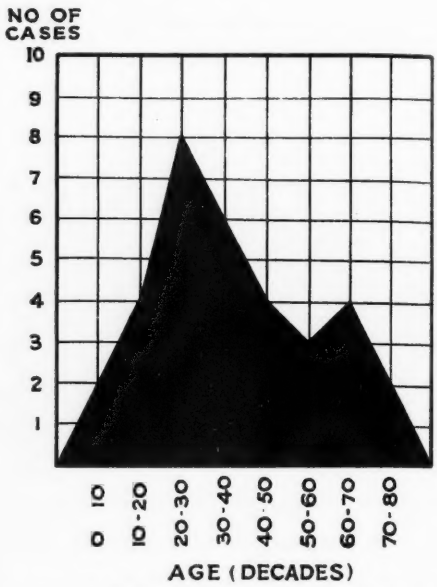


FIG. 340.—Priapism can occur at any time during life. It is most common in the early 20's.

TREATMENT

Should doubt exist as to whether the condition is due to a lesion of the central nervous system, a low spinal anæsthetic will settle the question, for priapism of neurogenic origin ceases when the cauda equina is paralysed. Priapism due to a nerve lesion rarely, if ever, requires for its relief any of the surgical measures about to be discussed.

Exposure and Division of the Pudic Nerves.—Although frequently listed in the literature as a method of treatment, there is no record of the procedure having been carried out.

Division of the Ischiocavernous Muscles.—This, again, appears to be entirely a theoretical concept. It certainly has never cured this condition.

Ligature of the Dorsal Arteries at the base of the penis near the symphysis was originally suggested and carried out by Bransford Lewis, of St. Louis, in 1897: his patient had "semi-priapism", which had been present for a year. It was Pryce, of St. Bartholomew's Hospital, who in 1902 gave prominence to this procedure, but it was not carried out by him; nevertheless, on his authority it has been recommended in a number of subsequent communications. Fundamentally unsound, ligature of the dorsal arteries (*Fig.* 341) favours gangrene of the penis and there is no evidence that it has ever relieved priapism other than in the case of "semi-priapism" cited above.

Aspiration of the Corpora Cavernosa.—In 1929 MacKay and Colston (1928) claimed satisfactory results in three consecutive cases by inserting a hollow needle into the shaft of the penis, aspirating stagnant, pitch-like blood, and then, by repeated injection and aspiration of saline solution, they aimed

at breaking up and removing fragmented clot. The operation can be carried out under a local anæsthetic but pentothal anæsthesia is to be preferred. The right corpus cavernosum is treated first (*Fig.* 342). The needle is then thrust through the septum, and

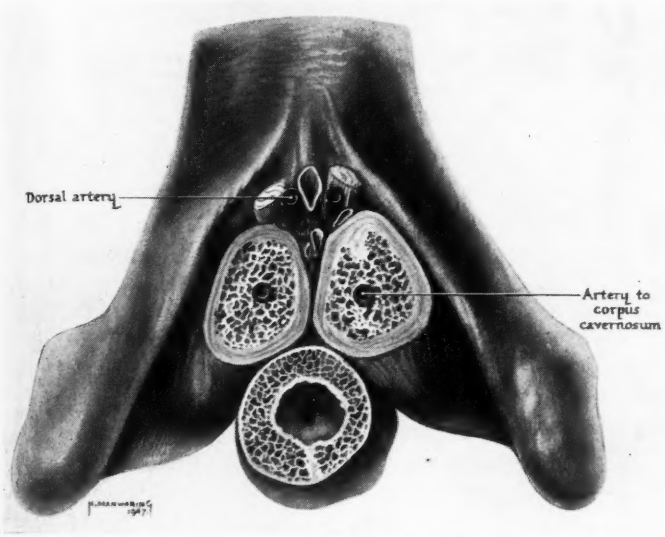


FIG. 341.—Ligation of the dorsal arteries is fundamentally unsound. Ligature of the arteries to the corpora cavernosa, which is impossible, would be more logical.

the left corpus cavernosum is dealt with in a similar way. Instead of using normal saline solution, citrate solution seems more harmonious with the principles involved. Partial or complete deflation having been

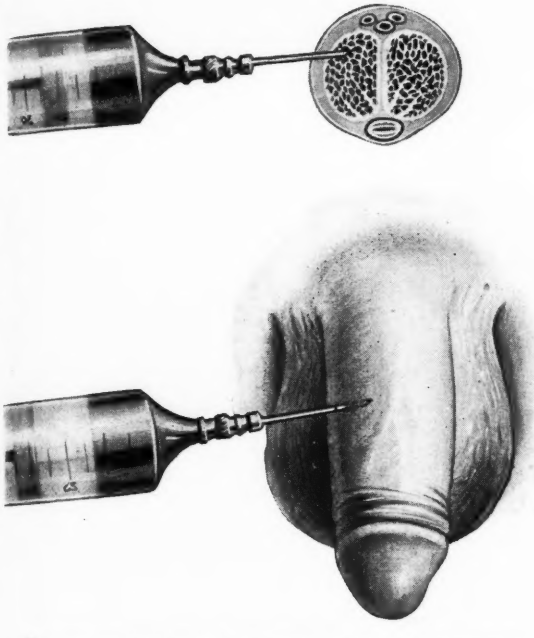


FIG. 342.—MacKay and Colston's method of deflating the penis by aspiration followed by injection irrigation.

obtained, a firm bandage is applied. It should be especially noted that it is highly probable the condition will recur and that the procedure must be repeated in 24–48 hours. In nearly all cases, at least three treatments will be required. This must be explained to the patient.

Many surgeons have found this method highly unsatisfactory; on the other hand, it would appear that not a few of them have failed to appreciate that the procedure must be painstaking and that several sessions are required. Obviously this treatment will offer a better prospect when it is commenced really early, i.e., during the first 48 hours. After many days it is probable that thick clots are present in the spongework, and they cannot be broken up.

I have tried the method on three occasions. In two instances the patient discharged himself after the third aspiration had failed to bring relief. In the third case I abandoned aspiration in favour of incision. It is probable that non-success of this method is in part due to the employment of an unsuitable needle; Boyer and Donovan (1930) used with success a French's blood transfusion needle (*Fig.* 343), and this should become the standard instrument for this procedure.

Incision.—More successes have attended incision than aspiration; even so, incision is not by any means a panacea. Where to incise, how to incise, and whether or not to drain has never been clearly stipulated, and here again the poor general results are in part due to inexact technique. It will be recalled that 123 years ago Thomas Callaway (1824) made a perineal incision into the crus; all latter-day operators have incised the shaft.

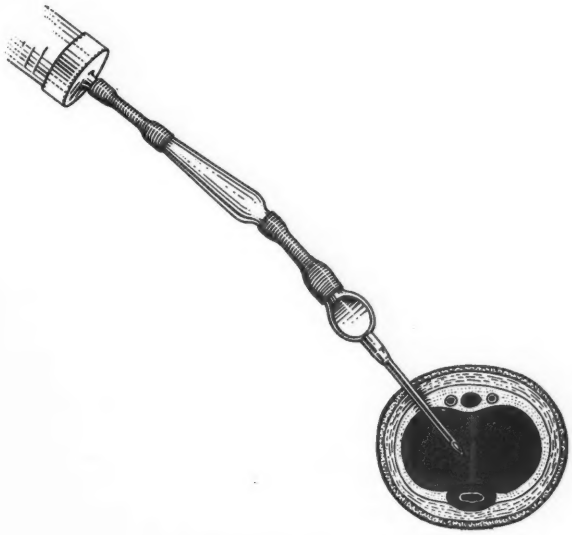


FIG. 343.—Owing to its adequate calibre, a French's or Keynes' blood-transfusion needle offers a better prospect of removing clotted blood by aspiration and injection. Because a Record syringe does not fit this needle, a glass adaptor must be employed.

Probably the greatest mistake that numbers of more modern operators have made, and I am among them, is to sew up the incision after blood and clots have been evacuated. Frequently a hæmatoma

forms; this invites infection and favours gangrene and septicæmia.

It goes without saying that asepsis should be as perfect as possible. Even so, both my cases treated by incision developed gangrene—I suspect that one of them was due to the concomitant ligation of the dorsal arteries.

From my study of the subject I recommend incision: (*a*) when aspiration has failed; (*b*) when the priapism has been present for a week or more.

The operation should be carried out under pentothal or general anæsthesia. The incision, made with a narrow sharp-pointed scalpel, should not be more

FIG. 344.—The incision into the corpora cavernosa should be a small one, and the insertion of a drainage tube is recommended.

than half an inch long; it should penetrate to the centre of the crus a little behind the middle of the shaft of the penis. A small hæmostat is introduced into the incision, and by its aid clots are evacuated by squeezing. A drainage tube is stitched into place (*Fig.* 344), and after sprinkling with sulphanilamide powder the penis is surrounded by a liberal damp antiseptic dressing. Subsequent dressings should be undertaken in the operating theatre. Prophylactic penicillin therapy is commenced forthwith.

ADJUVANT THERAPEUTIC MEASURES

Dicoumarin should be prescribed. There is no record that this drug has been used in priapism, but G. Leander informs me that it was recently employed alone in a case at Stockholm, and the priapism abated within a week. It is difficult to understand how this anticoagulant, which takes three days of administration to become effective, can dissolve the clot. Its value appears to lie in the prevention of clot re-forming.

Diathermy per rectum was employed by Riches (1930) in a man, aged 49, who had discharged himself from St. Peter's Hospital. The treatment was started on the thirty-fourth day of the erection. With the electrode in the rectum, the local temperature can be raised to 104° F. for 20 minutes each day. Riches was impressed by the good effect of this therapy, which should be tried when facilities for it exist.

TREATMENT OF PRIAPISM COMPLICATING LEUKÆMIA

Deep X rays directed to the spleen are stated to have proved beneficial in aiding the relief of the priapism, but usually one or other of the local measures detailed already must be invoked in addition.

THE ONSET OF GANGRENE

Gangrene developed in both my cases treated by incision. A number of similar cases are reported in the literature. Probably many more ending in septicæmia and death have not been recorded.

My first case of gangrene of the penis occurred in a man of 72. Aspiration of the erect penis being unsuccessful, I incised the corpus cavernosum, and, after evacuating clots, closed the incision. A hæmotoma formed and a few days later it became infected. I conceived the idea of putting the penis in a specially made Bunyan's bag, and irrigating the organ with hypochlorite solution; this was a failure. Amputation of the penis did not prevent septicæmia and death.

The second case, occurring in a man of 55, was more successful. Because he was mentally unbalanced on account of pain, narcotics, and catheterization, and had discharged himself from hospital, I performed primary incision, together with ligation of the dorsal arteries and suprapubic cystostomy. These measures were successful in relieving the painful priapism, but when the dressing was undone in the theatre on the 5th day, it was evident that gangrene

FIG. 345.—Commencing gangrene following incision of a corpus cavernosum with suture combined with ligation of the dorsal arteries.

of the penis (*Fig.* 345) was commencing. Amputation of the penis (*Fig.* 346) was therefore undertaken on the following day. His subsequent progress was satisfactory (*Fig.* 347). The patient has remained in good health and is able to micturate in the standing position by means of the small stump of corpus spongiosum that was preserved (*Fig.* 348).

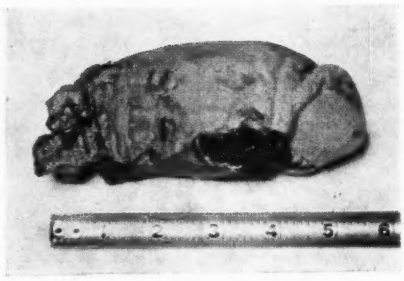


FIG. 346.—The penis amputated, showing gangrene.

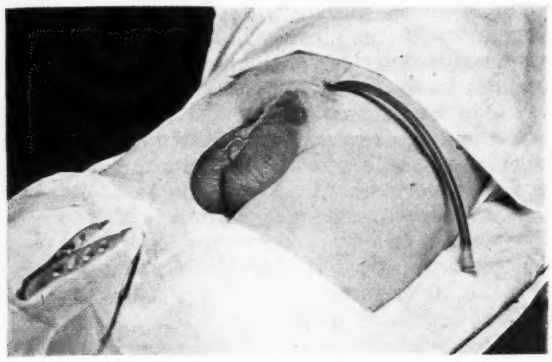


FIG. 347.—Ten days after amputation.

FIG. 348.—The patient utilizes the small stump of corpus spongiosum to good advantage when emptying his bladder.

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POSTERIOR GASTRO-ENTEROSTOMY FOR ORGANIC PYLORIC STENOSIS

A REVIEW OF THE END-RESULTS OF 80 CASES

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For a considerable time now, especially among the German and American surgeons, the cult of subtotal gastrectomy in the treatment of peptic ulcer to the exclusion of gastro-enterostomy has been gaining ground (Allen, 1942; Hinton, 1946; Lewisohn, 1923). Modern methods of blood transfusion and anæsthesia, aided by advances in chemotherapy, make this erstwhile formidable procedure relatively safe even in the hands of surgeons of small experience. Not only, however, is its universal applicability in the surgical treatment of peptic ulcer still in doubt, and its technique the subject of controversy, but its results as regards over-all mortality, complications, and residual disabilities such as pernicious anæmia, persistent flatulence, deficiency diseases, and hypoglycæmic attacks, have still to be assessed.

The simpler procedure of gastro-enterostomy has had its ups and downs, its past abuses, and its present limitations. The usefulness, therefore, of a review of the results of gastro-enterostomy in established cases of pyloric stenosis seems appropriate.

This paper concerns itself with a consecutive unselected series of operations for pyloric stenosis performed by a number of different surgeons on the staff of the Liverpool Royal Infirmary between the years 1928 and 1938. In cases of long-standing pyloric stenosis it is not always possible to identify an ulcer. From the results of this investigation, we feel that it will serve no useful purpose to divide this series of cases into groups depending on whether an ulcer was identified or not.

In spite of the fact that most of the failures of posterior gastro-enterostomy or partial gastrectomy occur within two years of operation, we are convinced that in order to get a true perspective of the value of gastric surgery, it is essential to have a follow-up of from ten to twenty years before a cure can be pronounced. Relapses do occur occasionally even at this late period.

Organic pyloric stenosis commonly is the result of a long-standing duodenal ulcer which in the process of healing occludes the pylorus, with resulting gastric hypertrophy and dilatation. The scarring may be so great that the pylorus only admits a bristle. The patient is subjected to slow starvation and dehydration. Pain is not a characteristic symptom unless the ulcer is showing activity. Copious vomiting occurs in the majority of cases and the gastric delay is manifested by the appearance of the previous day's undigested food in the vomitus. Alkalosis, tetany, and extrarenal azotæmia result from the vomiting. Epigastric fullness with occasional visible peristalsis may occur. In all cases, 'splashing' can be demonstrated when the stomach should normally be empty. There may be marked diminution or absence of chlorides in the urine. Radiologically there is marked delay even up to twenty-four hours in emptying of the stomach, which is grossly enlarged and shows deformity or irregularity of the duodenal cap. Fractional test-meal usually reveals hypochlorhydria or achlorhydria, although in rare cases hyperchlorhydria may occur.

Long-standing pyloric stenosis does not respond to medical measures. The obstruction is organic, although in some cases a certain amount of spasm may be superimposed. Operation is essential; in fact, it is a life-saving measure. With adequate pre-operative therapy, correcting the dehydration, alkalosis, and extra-renal azotæmia, no case, however ill, need be refused operation. A gastro-enterostomy if necessary, using local and splanchnic block, need have a mortality no greater than 1 per cent.

TYPE OF OPERATION

All cases under review were treated by a posterior no-loop vertical isoperistaltic gastro-enterostomy with a large stoma. A large stoma is necessary, since the stomach on regaining its tone contracts and, on doing so, narrows the stoma. No attempt was made to treat the cause of the pyloric stenosis. Pyloroplasty, invagination, cauterization, excision of the ulcer, and occlusion of the pylorus were considered unnecessary. In the majority of cases the ulcer had 'burnt' itself out and had only manifested itself by the mechanical defect it had produced during its natural cure.

From 1928 to 1938 80 cases of organic pyloric stenosis were treated by this method.

RESULTS

The results of the follow-up are shown in *Table I*. The patients who were not traced had either left their homes or died, or had been killed during air-raids. It cannot therefore be argued that there were many uncured patients who did not reply because they believed that an unsatisfactory operation was the cause of their not being cured.

Table I.—Results of Gastro-enterostomy in 80 Cases

Number of patients	not traced	15 (18·7 per cent)
" " "	traced	63 (78·7 per cent)
" " "	alive over 10 years	54 (66·75 per cent)
" " "	died within 10 years	9 (11·5 per cent)
" " "	" as result of operation	2 (2·5 per cent)

CLINICAL IMPRESSION

The general impression gained from taking the history of these ex-patients is that gastro-enterostomy

is definitely worth while, and this, as shown later, is confirmed by the figures. Most of these patients expressed spontaneously their gratitude for the operation. All answered that the operation had benefited them and had given them a new lease of life. The immediate post-operative period is nearly always uneventful. It rarely gives rise to any anxiety. The relief is dramatic and the results most gratifying. The average period of convalescence after operation is four weeks. In partial gastrectomy it is much longer—three to four months (Watson, 1947). All the patients traced returned to their former employment. Only one subsequently lost three weeks' employment due to a hæmatemesis. After an initial gain in weight, the weight remained stationary. The diet was a normal mixed diet, although two patients found that meat produced a small amount of discomfort and consequently they avoided it. Anæmia, apart from one case, and vitamin deficiency were conspicuous by their absence. Surprisingly, there was no evidence of the so-called ' dumping-syndrome ' which occurs in 5–12 per cent of cases after subtotal gastrectomy (Caster, Butt, and Waugh, 1946). The number who smoked and consumed alcohol appeared to be similar to that found in the normal population.

MORTALITY

Two deaths occurred from the operation, making a mortality of 2·5 per cent.

Case.—F. R., female, aged 67. Posterior gastro-enterostomy, Oct. 18, 1935. General condition very good post-operatively until ten days later, when she suddenly died from pulmonary embolism.

Case.—J. V., male, aged 74. Posterior gastro-enterostomy, Sept. 15, 1930. Developed sudden abdominal pain with diffuse board-like rigidity two weeks after operation. His general condition was extremely poor and operation was considered inadvisable. Post-mortem findings were general peritonitis with a large active ulcer causing pyloric stenosis. The posterior gastro-enterostomy showed no evidence of a leak.

Summary of Cases who had died within Ten Years of Operation.—

Case.—S. P., female, aged 66. Died one year after operation from carcinoma of rectum and secondaries in liver. Her operation had given her no relief.

Case.—A. W., male, aged 53. Killed by enemy action two years after operation. His relatives report that after the operation he had no pain, no vomiting, his apppetite had improved, and he was able to discontinue medical treatment.

Case.—H. J., male, aged 49. Died from carcinoma of stomach six years after operation. His vomiting and pain were relieved until shortly before his death.

Case.—T. C., male, aged 72. Died from pneumonia three years after operation. As far as his gastric symptoms were concerned, he was cured.

Case.—R. P. W., female, aged 55. Re-admitted a few weeks after discharge from hospital with cholecystitis. Cholecystectomy was performed and the gastro-enterostomy stoma was examined and found to be functioning well and admitted three fingers. On the fifteenth post-operative day she developed obstructive vomiting and died six days later.

Case.—P. W., male, aged 47. Died from myocardial degeneration six years after operation. Dyspepsia cured.

Case.—T. F., male, aged 54. Died four years after operation. Cause not given.

Case.—W. G., male, aged 43. Died eight years after operation from cardio-aortic specific disease with congestive failure. He had no dyspeptic symptoms except flatulence, which appeared at the onset of congestive failure.

Case.—W. P., male, aged 62. Died nine years after operation from pneumonia. He was well up to the time of his death.

FUNCTIONAL RESULTS

In order to standardize the after-results of gastro-enterostomy the grading used is similar to that used by Pyrah (1934). (*Table II.*)

Grade 1.—Patients placed in this grade stated that they were perfectly fit, complained of neither pain nor vomiting. had good appetites, and were able to do their work.

Grade 2.—Patients placed in this grade were perfectly able to work and take normal food, but occasionally had a little abdominal discomfort or vomited after long intervals. There was in no case any suggestion of active ulceration. Patients placed in Grades 1 and 2 are accounted to have had satisfactory results.

Grade 3.—Patients in this grade complained of considerable pain of an irregular type, sometimes associated with vomiting, and restricted their diet, but the symptoms did not suggest the presence of active ulceration.

Grade 4.—Patients were placed in this grade who had symptoms which were exactly like those of the original ulcer—post-prandial pain which was relieved by food and remissions. Many had had hæmatemesis or melæna since operation and had subsequent treatment in hospital. Many of these patients undoubtedly had either a jejunal ulcer or recurrence of the original ulcer in the duodenum; in other cases the pain was probably due to mechanical causes.

Table II.—GRADING OF 54 CASES ALIVE AFTER 10 YEARS

Number of patients placed in Grade 1	50
" " " " " " 2	3
" " " " " " 3	–
" " " " " " 4	1

The number of cases of satisfactory results in patients alive over ten years after operation is 53 (98 per cent).

Consideration of Patients with Symptoms in Grade 2 (3 cases).—

Case.—G. W., male, aged 68. Posterior gastro-enterostomy in 1933 completely relieved until 1945. He then developed pain below and to the left of the umbilicus. It was not related to food and did not radiate; relieved by pressure. Aggravating factors not known. No vomiting or loss of weight. Appetite good. Re-admitted Jan. 28, 1947, for investigation. X-ray examination showed juxtapyloric ulcer with delay in emptying. Fractional test-meal showed some hyperchlorhydria. Intravenous pyelogram showed the presence of renal calculi. Urinalysis showed occasional leucocytes and R.B.C.s in deposit.

It is probable that the pain was caused by the renal calculi. The patient stated that his operation was of definite benefit and relieved his nausea and vomiting

which had not recurred. He was able to carry on with his work and declined further operative measures.

Case.—T. L. B., female, aged 64. Operation, 1931. Vomiting occurred at long intervals. She was X-rayed in 1940 and 1945 and nothing abnormal was found. She had no loss of weight and when examined recently she was asymptomatic.

Case.—S. C., male, aged 58. Operation, 1928. No complaints apart from occasional heartburn, relieved by alkalis.

Consideration of Patient with Symptoms in Grade 4.—

Case.—H. D., male, aged 63. Operation, 1928; had a hæmatemesis May 12, 1944. Occasional pain for which he took alkalis since his operation. He had only been off work for three weeks when he was admitted to hospital with hæmatemesis. No gastric investigations were performed.

POST-OPERATIVE COURSE

This was obtained from the case-sheet notes.

Post-operative Complications (*Table III*).—

Table III.—POST-OPERATIVE COMPLICATIONS

Uneventful	69
Minor complications	9
Major complications leading to death	2

Major Complications.—The cause of the two deaths has already been discussed.

Minor Complications.—Wound sepsis occurred in 1 case; the wound was healed fourteen days after operation. Vomiting occurred in 2 cases—no operative interference required. Distension and bronchitis were present in 5 cases.

Case.—E. K. W., female, aged 49. Operation, March 29, 1934. Developed surgical emphysema of neck and chest wall. This ultimately cleared up without any residual disability.

There was no mention of post-operative hæmorrhage due to bleeding from the stoma or the ulcer.

The incidence of vicious-circle vomiting in absolute pyloric stenosis theoretically should be negligible as the pylorus has naturally become occluded. Provided posterior gastro-enterostomy is performed in the correct type of case with ordinary care and skill, so that the jejunal loop is neither too long nor too short nor rotated on its long axis, and the stoma and the opening in the mesocolon planned correctly, regurgitant vomiting should be avoided. Acute dilatation of the stomach and paralytic ileus should be prevented by timely use of gastric suction and intravenous fluids.

Late Complications (*Table IV*).—

Table IV.—LATE COMPLICATIONS

Anæmia	1
Carcinoma ventriculi	1
Jejunal ulceration	0
Gastrojejunocolic fistula	0
Retrograde intussusception	0
Hæmatemesis	1
Gastritis hypertrophica	0
Peritoneal adhesions	1
Post-P.G.E. pain	1

Anæmia.—Clinically, apart from 1 case, there was no evidence of anæmia, probably due to the fact that the diet was not restricted.

Case.—J. H., male. Operation, 1928. Found on routine examination to have marked pallor of skin and mucous membranes. His spleen was not enlarged and he had no symptoms. Blood-count showed hæmoglobin 68 per cent, and R.B.C.s 4·8 million per c.mm. The blood-picture suggested iron deficiency.

Carcinoma Ventriculi.—

Case.—H. J. Case history given above. The carcinoma probably developed on his ulcer. The ulcer identified at operation was situated in the pyloric antrum.

Peritoneal Adhesions.—

Case.—H. G., female, aged 39. Posterior gastro-enterostomy Nov. 16, 1933. Re-admitted Jan. 16, 1934, with recurrence of vomiting and feeling of distension. At operation, numerous adhesions of omentum to a previous suprapubic incision (for hysterectomy) were found incarcerating loops of small gut intermittently. The G. E. stoma was normal and patent. When the adhesions were separated she made an uninterrupted recovery and when examined recently (April 16, 1947) stated that she was completely relieved and doing her work as a typist.

Hæmatemesis.—This case has already been discussed.

Post-posterior Gastro-enterostomy Pain.—

Case.—D. L., male, aged 37 at time of operation (1931), was re-admitted in 1934 with epigastric pain and vomiting. History suggestive of recurrent ulceration. Radiological report: "Food leaving stomach via P.G.E. and pylorus. Adhesions around the pyloric end. P.G.E. empties slowly, considerable amount in stomach at three hours." He was put on a post gastric-ulcer régime, and when examined in May, 1947, he was completely symptom-free.

DISCUSSION

No patient was refused operation because of general disease rendering him too great an operative risk. There was 1 case operated upon below thirty years, 3 cases between thirty and forty, and 76 cases over forty years. (*Table V.*)

Table V.—AGE AT OPERATION

Average age at time of operation	50½ years
Age of youngest patient at time of operation	25 ,,
Age of oldest patient at time of operation	74 ,,

It is generally recognized that gastric surgery below thirty years is best avoided. In the presence of mechanical obstruction, the results of posterior gastro-enterostomy, provided there is no hypertrophic gastritis or increase of acidity, should be good at any age, apart from infancy.

This review shows that posterior gastro-enterostomy is the ideal operation for mechanical stenosis. The operation has now stood the test of time, as it has been practised for sixty-six years from the time of its introduction by Wölfler, at Nicoladoni's suggestion. The foundation of the modern operation was laid by Peterson in 1900. Our figures confirm Wilkie's statement that where duodenal ulcers were associated with some stenosis one can anticipate 90 per cent of satisfactory results. As yet, the late results of extensive partial gastrectomy performed on both young and middle-aged persons are unknown. Balfour (1944) estimates 9 per cent recurrence of ulcer after partial gastrectomy. Reinhoff (1945) found 8 per cent of chronic duodenal ulcers completely resistant to both partial gastrectomy and medical therapy. Kieper (1942) found 6·8 per cent jejunal ulcers and 4·6 per cent post-operative

hæmorrhage—no ulcer being demonstrated after partial and subtotal gastrectomy. He concludes by stating that although the incidence of recurrent ulcer, after radical resection of the stomach, is lower than after gastro-enterostomy, the post-operative ulcer problem is still unsolved. The type of case appears to be as important as the selection of the operation, since it is noted that the group of cases in which jejunal ulcer develops after gastro-enterostomy also shows the highest incidence of post-operative ulcer when the patient is subjected to subtotal gastrectomy. In this country, Walton's carefully controlled follow-up results (1944) shows an incidence of 4 per cent gastrojejunal ulceration after posterior gastro-enterostomy for duodenal ulcer with or without stenosis. These results have been fairly constant from the time his cases numbered two hundred to the present, when they number over a thousand. It is therefore not justifiable to subject every case of pyloric stenosis to a subtotal gastrectomy as a prophylactic measure against gastrojejunal ulceration. The death-rate from this operation, and the morbidity which follows it, do not warrant the more radical measure when the comparatively simple operation of posterior gastro-enterostomy gives such gratifying results. In the indurated duodenal ulcer which is of cartilaginous hardness and so adherent to the common bile-duct, or so involving the ampulla of Vater, that its resection would result in resection of the common bile-duct and pancreatic ducts, a first-stage anterior gastro-enterostomy or even a gastro-enterostomy as a permanent measure is justifiable (Lahey, 1945).

The danger of carcinoma developing in the stomach after posterior gastro-enterostomy has been exaggerated. The incidence of carcinoma developing in cases of peptic ulceration treated medically is about 2 per cent (Smith, 1928). The incidence of carcinoma of the stomach after partial gastrectomy is 3 per cent (Balfour, quoted by Rodney Maingot). As pyloric stenosis is virtually always duodenal stenosis (Moynihan, 1923), it is unlikely for carcinoma to develop, as the incidence of gastric carcinoma in the presence of duodenal ulcer is negligible. Because of the high incidence of carcinoma in ulcers of the pyloric antrum, it is better to perform a subtotal gastrectomy even in the presence of pyloric stenosis. Some 90 per cent of ulcers proximal to the pyloric canal, but within about an inch of it, are malignant (Holmes and Hampton, 1932).

In order to obtain the best results from posterior gastro-enterostomy for pyloric stenosis, it is essential for the diagnosis to be established. A fractional test-meal should always be performed, because in the presence of hyperchlorhydria there is the danger of gastrojejunal ulceration. Gastroscopy is valuable in demonstrating the degree of rugosity of the stomach. Excess of gastric folds seems to be the cause of gastrojejunal ulceration after gastro-enterostomy (Herman Taylor, 1944). Plasma-protein estimation is useful in that if any abnormality is detected, this can be corrected pre-operatively by giving intravenous hydrolysed protein. Decrease of urinary chlorides, dehydration, raised N.P.N., and alkalosis will require intravenous chlorides to correct the disturbance in the acid-base ratio of the blood and tissue fluids. The administration of sodium chloride results in the rapid excretion of the excess bicarbonate and N.P.N. in the urine (Samson Wright, 1936). Washing out of the stomach and emptying it of its contents will avoid the danger of aspiration of the gastric contents into the lung during induction of anæsthesia. This catastrophe, although rare in the hands of an expert anæsthetist, does occur from time to time. Its incidence was estimated to be 0·15 per cent in 44,016 cases (Mendelson, 1946). The technique of the modern posterior gastro-enterostomy is so well known that it will not be pertinent to add more than previously stated. Post-operative hourly aspiration through a Ryle's tube is useful as a prophylactic measure in preventing acute dilatation of the stomach, regurgitant vomiting of paralytic ileus, and the temporary œdema of the stoma. In the majority of cases the patient is fit for discharge on the fourteenth day. After three months' post-gastric régime, a normal mixed diet can be resumed.

CONCLUSION

Posterior gastro-enterostomy is still the ideal operation for organic pyloric stenosis.

Ninety-eight per cent of the patients alive over ten years after operation were considered to have satisfactory results.

The operative mortality was 2·5 per cent.

The case histories of the deaths and the late complications are given.

The post-operative course of the operation is discussed.

The average age of the patients at the time of operation was 50½ years.

Suggested investigations to determine which cases are suitable foı posterior gastro-enterostomy are outlined and pre- and post-operative treatment to give the best results is indicated.

With modern anæsthesia, chemotherapy, and adequate pre- and post-operative measures, the operative mortality should not be more than 1 per cent.

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MESENTERIC CYSTS

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THE subject of mesenteric cysts has now a voluminous literature, and despite the fact that standard text-books make little or no mention of the condition, there are in the literature several able reviews of the subject (Dowd, 1900; Higgins and Lloyd, 1924; Warfield, 1932). Mesenteric cysts are admittedly rare, and many surgeons would have spent a surgical lifetime without encountering a single case. On the other hand de Pena (1924) recorded four cases of his own, and several writers have had two or three cases each.

The first case of mesenteric cyst to be recorded was that of Benivieni, a Florentine anatomist, who described a cyst discovered at autopsy in 1507. Since that time these cysts have continued to interest on account of their rarity and their interesting problems of aetiology, diagnosis, and treatment. By definition a mesenteric cyst is a cyst situated between the leaves of the mesentery of the small or large intestine. A retroperitoneal cyst could not be clearly differentiated from a mesenteric cyst, more particularly as many segments of the large bowel have no mesentery, and cysts arising in relation to them would necessarily be retroperitoneal. Mesenteric cysts and retroperitoneal cysts are well defined and only attached by loose areolar tissue to neighbouring structures, enabling them to be clearly distinguished from pseudo-pancreatic cysts and renal cysts, which are attached to the respective viscera from which they originate.

The mode of origin of the mesenteric cyst is difficult to decide. The typical fluid of these cysts is a pale, clear, straw-coloured serum of specific gravity 1015 to 1016, alkaline in reaction, and containing a large amount of albumin (Moynihan, 1897). Chylous cysts are common, forming nearly half the recorded cases. Moynihan supposed that mesenteric cysts were formed by dilatation of lymph-channels or by enlargement of a cystic space in a degenerate lymph-gland. It has never been proved possible to produce a lymph-cyst experimentally by obstruction of lymphatic vessels in the mesentery, as the anastomosis is so rich and free. Dowd (1900) pointed out that chyle could be effused into a preformed cyst. Higgins and Lloyd (1924) consider that such adjectives as lymphatic, chylous, or sanguineous, though frequently used, merely denote accidents which may befall any cyst, and though picturesque they have no precise bearing on the problems of aetiology and serve no useful purpose. Most subsequent writers have followed Dowd, and mention the lymphatic theory only to criticize it. A chylous or serous cyst need not, however, be the result of mechanical obstruction. It could be regarded as a lymphangiomatous cyst, like the solitary lymphatic cysts of the neck.

Moynihan suggested that some cysts could be produced from hæmatomata in the mesentery; and Genkin (1928) records a chylous cyst produced around a swab retained in the abdominal cavity.

Another factor in helping to decide the origin of mesenteric cysts is the histological structure of the cyst wall. In some cases the cyst wall was found continuous with the intestinal mucosa and showed a structure identical with it (Miller, 1913; Hunter, 1922; Van der Bogert, 1909).

Lewis and Thyng (1907) showed that diverticula occur frequently in the embryos of pig, rabbit, and man, and sequestration of such diverticula could give rise to cysts. Another possible site of origin is from a Meckel's diverticulum. Although the precise mode of origin is not clear, the structure of the cyst wall in some of the cases leaves no doubt as to their origin from the intestinal mucosa.

Cysts with a lining of stratified epithelium and with cheesy matter filling their lumen could not be regarded as any other than dermoid cysts. They are the rarest of the cysts of the mesentery, there being only 16 cases on record in 1944 (James). It has been stated that these cysts occur in the female and that they therefore arise from the ovary, being ovarian dermoids. Cases of mesenteric dermoid cysts have, however, been reported in the male, and it is clear that all dermoids are not derived from the ovary. A serous cyst might have a lining of stratified epithelium, while the true dermoid often shows cartilage and other tissues in the wall besides epithelium, and there are often hairs mixed with the cheesy content of the cyst. The mode of origin of such cysts must still remain unsolved. Ewing (1934) suggests that they are imperfectly developed teratomas.

In 1900 Dowd suggested that mesenteric cysts could be produced from the persistence of embryonic rudiments of the pronephros and the mesonephros with subsequent displacement of the cyst forwards between the layers of the mesentery. This theory has attracted most subsequent writers, and this origin has been held to account for both the retroperitoneal as well as the mesenteric cyst. It has been suggested that the question would be settled by the finding of rudimentary glomeruli and kidney tubules in the walls of these cysts, or by the identification of urinary salts in the fluid of the cysts. The writer has not come across any records of cases in which such findings were found. In one case urea was present in the cyst fluid, but this finding alone would not prove that the fluid was excreted by the urogenital tract. The urogenital origin of these cysts is an interesting theory, which might well be applicable to many mesenteric and retroperitoneal cysts, but direct proof is still to be found for this hypothesis.

SYMPTOMATOLOGY AND DIAGNOSIS

It is not surprising that most cases of mesenteric cysts are not diagnosed before operation. Correct diagnoses have, however, been made occasionally and more diagnoses will be made in future if the occurrence of these cysts be borne in mind.

A cyst which had not given rise to complications might be too small to palpate, or it might be so large as to fill the abdominal cavity, rendering diagnosis difficult. In most such cases, however, there will be a well-defined central intra-abdominal cyst, usually with mobility greater in the transverse than in the longitudinal direction.

Complications are common. Intestinal obstruction may be produced by volvulus, intussusception, kinking adhesions, narrowing of the bowel by pressure of the cyst, or from impaction of the cyst in the pelvis. Intracystic hæmorrhages, infection of the cyst, and rupture into the peritoneal cavity are all complications which have been encountered in the recorded cases.

TREATMENT

Enucleation of the cyst would be the ideal treatment, and has proved practicable in many cases. Care must be taken to avoid injury to the mesenteric vessels during the dissection of the cyst wall.

Marsupialization of the cyst has been performed in some cases where dissection was considered too hazardous, and, strange to relate, the cyst has remained empty after this procedure. A similar result very occasionally attended simple aspiration of the cyst. In cases with involvement of the bowel by a complication, resection of the bowel together with the cyst has sometimes been done—a severe operation dictated by urgent necessity.

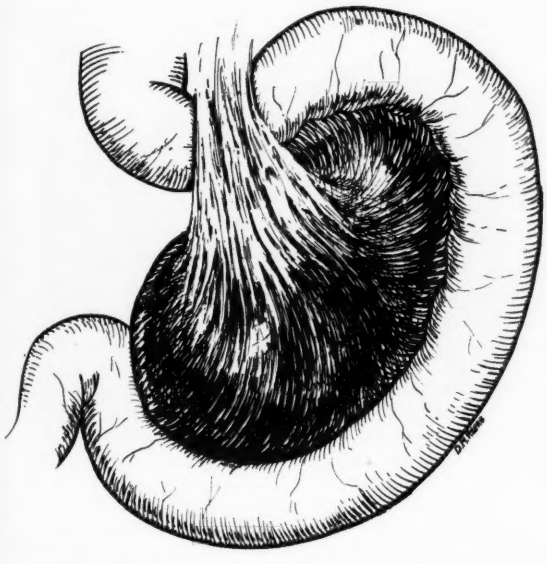

Fig. 349.—The cyst occupies the whole of the mesentery of the upper 2 ft. of jejunum, and a band of fibrous tissue crossing the duodenum to pass on to the cyst wall compresses the duodenum when the cyst is dragged downwards.

CASE REPORT

A mesenteric cyst which caused repeated attacks of acute intestinal obstruction from its recurrent impaction in the pelvis.

N. R. A. G., male Singhalese, aged 30, was admitted to the General Hospital, Colombo, on Jan. 21, 1947, complaining of incessant vomiting and lower abdominal pain of nine hours' duration. The onset had been sudden at 3 a.m. in the morning. During the past three months the patient had experienced six similar bouts of pain and vomiting. The first two attacks had lasted four hours, with an interval of three weeks between them, the third attack two weeks later lasted one and a half days. During the attacks, the very severe lower abdominal pain was eased by sitting up and leaning forwards. The vomiting would change from clear fluid to bile as time went on.

The patient was admitted in the first place to a medical ward as a case of abdominal colic. There was no rigidity or tenderness of the abdominal wall, and the patient was given an injection of morphine. A lump was noted in the lower abdomen the next day and was taken to be a distended bladder. More morphine injections were needed, as the pain continued unabated. So did the vomiting. The patient had a small bowel action, passing an amount the size of a fowl's stool. On the third day (Jan. 23) the patient passed blood per rectum. A rubber catheter passed into the bladder withdrew urine but left the hypogastric lump the same size. The patient was now referred to the surgical side.

The patient was seen to be in great agony, and he was markedly dehydrated. He was sitting up in bed leaning forward to ease the pain.

On Examination.—A round lump was felt in the hypogastrium rising out of the pelvis up to the level of the umbilicus. The percussion note over it was resonant. A rectal examination showed that this lump filled the rectovesical pouch. It was soft and easily ballotted between the rectal finger and the anterior abdominal wall. There was blood on the examining rectal finger. Although the lump was recognized to be of unusual shape and position for an intussusception, this was considered the most likely diagnosis, and operation was advised.

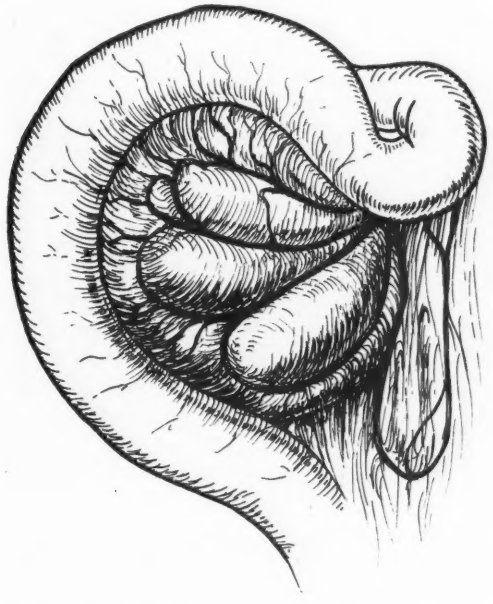

Fig. 350.—The mesenteric vessels lie under the left leaf of the mesentery, and on the surface of the cyst.

At Operation (Jan. 23).—Under light percaine spinal anæsthetic, a right paramedian incision was made in the lower abdomen. The peritoneal cavity was clean and dry. There was a large cyst rising out of the pelvis, with coils of small intestine in front of it. Closer inspection showed that the cyst was in the mesentery of the small intestine, and gentle traction on the bowel served to deliver the cyst from out of the pelvic cavity in which it was impacted. The cyst was seen to lie in the mesentery of the upper 2 ft. of the jejunum and it occupied the whole extent of the mesentery. The third part of the duodenum

was dilated to three times its normal size, and a band of fibrosis in the peritoneum compressed the duodenum as it passed over it to the cyst wall (*Fig.* 349). The cyst had bulged the right leaf of the mesentery, while through the left leaf the mesenteric vessels were viewed on the surface of the cyst (*Fig.* 350). The cyst was now delivered

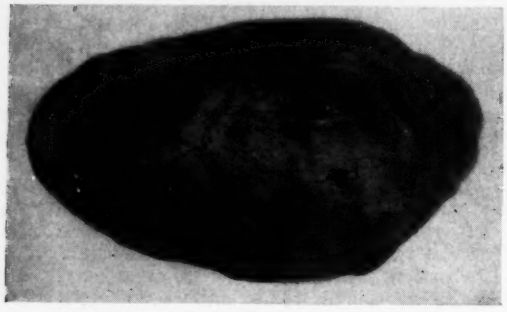

Fig. 351.—Photograph of the cyst after removal. The cyst wall has been filled with gauze. (× ½.)

out of the abdominal cavity, and an incision made through the right leaf of the mesentery, exposing the cyst wall. The cyst wall was enucleated, care being taken not to damage the mesenteric vessels. A small tear in the wall of the cyst caused a thick milky fluid to escape. This was collected in a sterile bowl, and the enucleation of

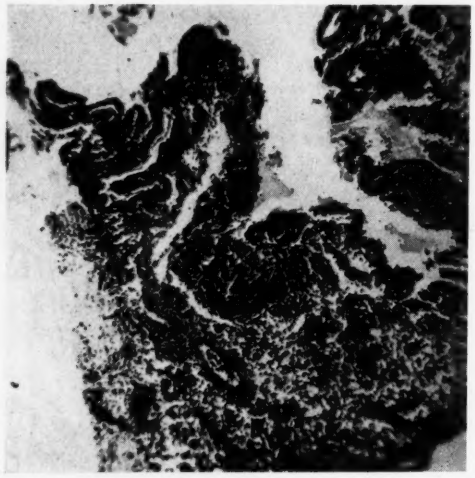

Fig. 352.—Photomicrograph of inner portion of wall of cyst showing columnar-celled epithelium with crypts lying on a bed of lymphoid tissue. (× 60.)

the now empty cyst was completed. The wound in the peritoneum of the mesentery was closed and the abdominal wound was sutured.

The fluid collected in the bowl amounted to 15 oz., and about 5 oz. were lost by leakage on to the towels. The fluid looked like unsweetened condensed milk.

The cyst wall was smooth outside, with small trabeculations on its inner surface (*Fig.* 351).

PROGRESS.—After the operation the patient continued to vomit several times, he passed several blood-stained stools, and his pulse was of a small volume. The abdomen was flat and not tender. A saline intravenous drip restored the pulse to normal, and from that time the patient made an uninterrupted recovery from the operation, leaving the hospital on Feb. 10.

THE SPECIMEN.—A small quantity of the cyst fluid was sent to Dr. W. D. Ratnavale, Pathologist, General Hospital, who made the following report: The specimen consists of 11 c.c. of a milky-white fluid, fairly alkaline in reaction and with a specific gravity of 1006. Under the microscope it was found to consist of numerous particles of molecular fat exhibiting Brownian movement and staining orange with Sudan III. There were a few delicate strands of what appeared to be coagulated fibrin. No cells or organisms found.

When shaken up with a few cubic centimetres of ether the turbidity almost entirely disappeared.

The fluid appears to be a highly concentrated specimen of chyle.

Histological Examination of the Cyst Wall: The cyst wall showed a lining of columnar-celled epithelium with glandular crypts penetrating a bed of lymphoid tissue, the whole mucosal lining resting on a well-defined wall of plain muscle-fibres (*Figs.* 352, 353).

Exclusion of filarial disease as a causative factor of the condition: Thick films of blood were taken at night on three occasions, but no microfilariæ were found in the blood.

Discussion.—This case is of great interest, both from the pathological and the surgical points of view. The histological structure of the cyst wall shows it to be a replica of the wall of the small intestine, and there can be no doubt that the cyst was produced by sequestration of the wall of the small intestine. On the other hand, the fluid content of chyle, which formed so striking a feature of the cyst as it was viewed on the operating table, suggested that the cyst was produced by the dilatation of a lacteal vessel. Such a view is completely negatived

Fig. 353.—Photomicrograph of outer portion of wall of cyst, showing plain muscle layer. (× 60.)

by the histological structure of the wall, and this case lends strong support to the view that the fluid content of the cyst is often an accidental circumstance determined by the opening up of lymph or chyle vessels into the lumen of the cyst.

The clinical picture of this case becomes quite clear when it is interpreted in the light of the operative findings, and yet clear cut as the symptoms were, they produced so rare a combination of events as to have defeated efforts at arriving at a correct pre-operative diagnosis. The repeated impaction of the large cyst in the pelvis gave rise to profuse and incessant vomiting of mucus and bile, without abdominal distension. The obstruction was due to a band of fibrous tissue passing over the third part of the duodenum which compressed this bowel when the cyst was displaced strongly downwards. The pressure of the impacted cyst on the rectal blood-vessels caused blood to be passed per rectum on the last day of

pre-operative observation. These now easily understandable features were combined with the finding of a large cystic tumour filling the pelvis and rising up to the level of the umbilicus, the whole making a very pretty syndrome in a rare and striking case.

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INTRAPERITONEAL HÆMORRHAGE OF UNUSUAL AETIOLOGY

WITH A REPORT OF TWO CASES

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MASSIVE intraperitoneal hæmorrhage is usually the result of an ectopic gestation or of direct trauma. Less commonly, it results from lesions of the female genital tract not associated with pregnancy, from acute pancreatitis, from rupture of an aneurysm, or from spontaneous rupture of a visceral artery.

The following cases illustrate two of the rarer causes of intraperitoneal hæmorrhage, and appear to be of sufficient interest to warrant detailed description.

CASE REPORTS

Case 1.—V. G., a married woman aged 25 years, was admitted as a surgical emergency to the Royal Infirmary, Sheffield, under the care of Professor R. St. Leger Brockman, on Oct. 16, 1946.

HISTORY.—The patient stated that forty hours prior to admission she was seized with sudden severe abdominal pain, which began in the epigastrium and spread rapidly over the whole abdomen. There was no history of injury. The pain remained present continuously ever since, though its intensity diminished somewhat a few hours after the onset. The day before admission she felt extremely weak and fainted. Shortly after this she vomited once.

The bowels were regular and there was no disturbance of micturition. Her menstrual period was one week overdue. Previous periods had been regular (every 26 days) and normal. She had no children. Her husband had come home from service overseas three months previously, and sexual intercourse had taken place regularly since his return.

ON EXAMINATION.—The patient showed characteristic signs of intraperitoneal hæmorrhage. She was pale, restless, and anxious looking; the pulse was moderately rapid (100 per minute) and of poor volume; the blood-pressure was 130/90 mm. Hg (later falling to 100/60), and the temperature normal.

The abdomen was moderately distended, tumid, and generally tender, and there was dullness in both flanks. On vaginal examination there was some tenderness in the left fornix but no other abnormality. There was no evidence of cardiovascular disease.

A diagnosis of ruptured ectopic gestation was made and the patient prepared for operation.

OPERATION (M. W.).—The abdomen was opened through a right lower paramedian incision. The peritoneal cavity contained between two and three pints of blood, and when this was removed the ovaries and tubes were examined and found to be perfectly normal, except for a yellowish nodule, about 1 cm. in diameter, in the left ovary—apparently a corpus luteum. Further search for the cause of the bleeding revealed a dark-red oval mass, measuring about 3 cm. in its long axis, from which blood was oozing, in the angle between the inferior aspect of the transverse colon and the posterior surface of the great omentum. The mass was firmly attached to both these structures, and there were numerous thin-walled omental vessels in close relationship to it.

The mass was thought to be either the sac of a primary abdominal pregnancy or possibly an endometrioma. It was excised, together with a piece of omentum and a small area of the peritoneal coat of the transverse colon, as separation from the latter could not otherwise be effected. The peritoneal surface of the colon was reconstituted, the gap in the omentum repaired, and the abdomen closed without drainage.

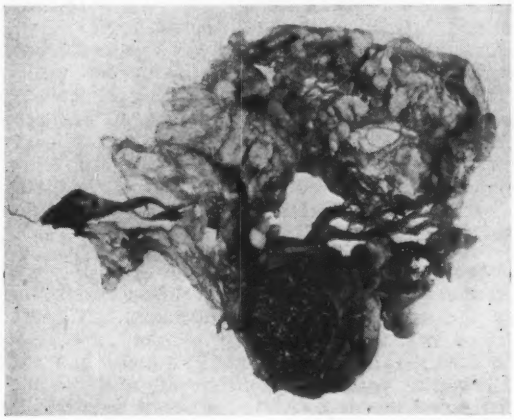

FIG. 354.—Aneurysm of omental artery. A portion of the wall has been removed to show the blood-clot within the sac. (× 0·7.)

A transfusion of three pints of blood was given and, apart from some constipation and colicky pain, the patient made an uneventful recovery. She was discharged from hospital on Oct. 29, 1946, and her periods recommenced during December.

PATHOLOGICAL EXAMINATION.—The specimen was sent, in the first instance, to Professor F. Davies, Head of the Department of Anatomy, University of Sheffield, who made a very careful examination but could find no

evidence of an ovum. It was then examined by Dr. L. C. D. Hermitte, Pathologist to the Royal Infirmary, who reported as follows :—

"The specimen has the appearance of a cyst with a smooth lining, and filled with blood-clot. Sections taken from two different parts show a fibrous wall varying in thickness and infiltrated with extravasated blood. No definite endothelial lining. No evidence of endometriosis. The cyst appears to be of simple nature." *Fig.* 354 shows the macroscopical appearance of the specimen after opening the sac.

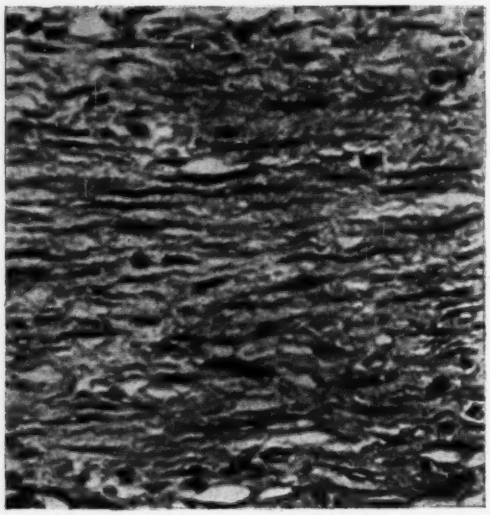

FIG. 355.—Aneurysm of omental artery. Low-power view of a section of the sac wall, showing marked infiltration with blood. (Van Gieson's stain.) (× 37·5.)

The clinical and operative findings did not seem to be compatible with the diagnosis of a simple cyst and the writer suggested that the specimen might possibly be an aneurysm. Further sections, coloured photographs of which are reproduced in *Figs.* 355, 356, were therefore made and stained with Van Gieson's and Mallory's stains, and in these Dr. Hermitte was able to demonstrate numerous smooth muscle-fibres in the sac wall. On the basis of this and the other pathological features, he agreed that the specimen was, in fact, an aneurysm.

Careful dissection of the surrounding omentum failed to reveal continuity between the sac and any of the vessels in relation to it, but this may well have been due to the fact that the specimen had been extensively handled in the search for an ovum before this dissection was made.

Case 2.—M. F., a married woman aged 38 years, was admitted as a surgical emergency to the Royal Infirmary, under the care of Professor Brockman, on March 8, 1947.

HISTORY.—The patient stated that she had suffered from low back pain for three months, and that she had had irregular uterine bleeding for about the same length of time. She had two children aged respectively 10½ and 9 years. Six hours prior to admission, she was seized with severe lower abdominal pain, which passed through to the back and was made worse if she straightened her legs. There was no history of any injury and she had not vomited. Her bowels were regular and there was no disturbance of micturition.

ON EXAMINATION.—The patient was very pale and restless and looked desperately ill. The pulse was almost imperceptible, but the heart-rate was remarkably slow (56 per minute). The blood-pressure was 90/50 mm. Hg.

The abdomen moved poorly with respiration and there was generalized tenderness and rigidity, most marked below the level of the umbilicus. There was some dullness in the flanks, but this did not shift on moving the patient. On rectal examination, a very tender mass was felt in the pouch of Douglas. A vaginal examination was not made.

The provisional diagnosis made was ruptured ectopic gestation or twisted ovarian cyst, but on looking back it seems that the correct diagnosis, namely, intraperitoneal hæmorrhage from a uterine fibroid, might well have been suspected by a surgeon aware of this condition.

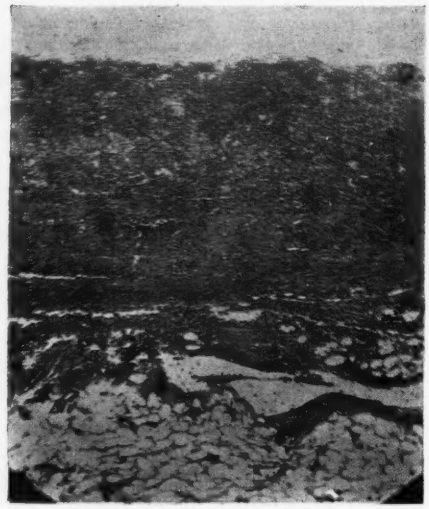

FIG. 356.—Aneurysm of omental artery. High-power view of a section of the sac wall, showing yellow-staining smooth muscle-fibres intermingled with bundles of connective tissue. (Van Gieson's stain.) (× 375.)

OPERATION (M. W.).—Blood transfusion was started in the theatre and the abdomen was then opened through a left lower paramedian incision. The peritoneal cavity contained about three pints of blood. The mass in the pelvis was seen to consist of a large subperitoneal fibroid growing from the posterior aspect of the uterus. On the surface of the fibroid there was an enormously dilated thin-walled vein, which had ruptured, and from which blood was gushing in a continuous stream at an alarming rate. The tubes and ovaries appeared normal.

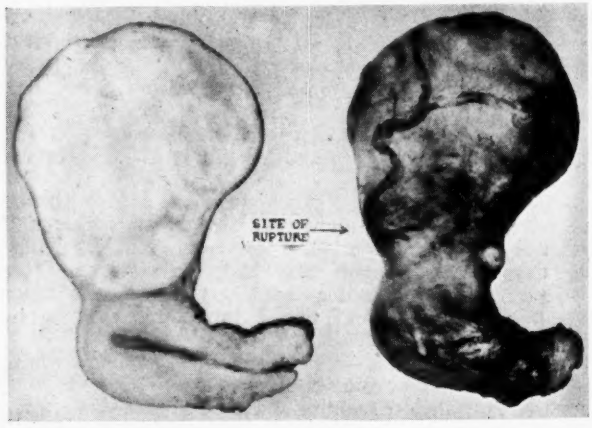

FIG. 357.—Uterus with subperitoneal fibroid. On the surface of the tumour there is a large thin-walled vein, which had ruptured at the point shown, causing severe intraperitoneal hæmorrhage.

Hæmorrhage was controlled temporarily by pressure, the blood sucked up, and, as the patient's condition had

improved considerably, subtotal hysterectomy performed. The abdomen was closed without drainage.

The patient made an uneventful recovery and was discharged from hospital on March 24.

PATHOLOGICAL EXAMINATION.—The specimen, a photograph of which is shown in *Fig.* 357, consists of the uterus with a single large subperitoneal fibroid. The vein which had ruptured was situated on the surface of the tumour, immediately subjacent to the peritoneum.

DISCUSSION

Rupture of an aneurysm of an abdominal vessel is decidedly rare. Taylor (1945), in a review of the literature, states that the arteries most commonly involved are the splenic and renal. He refers, however, to 69 cases in which the vessel concerned was the hepatic artery, 33 in which it was the cœliac artery, and 5 in which it was the cystic artery, and himself reports 1 case of rupture of an anastomotic aneurysm of the right and left gastric arteries. As far as can be ascertained no case of aneurysm of an omental vessel has previously been reported.

Spontaneous rupture of an abdominal artery in the absence of an aneurysm is even rarer than ruptured aneurysm. Marks and Freedlander (1945) have reviewed 26 reported cases and have described 3 cases of their own. Of the latter, all three had arteriosclerosis with associated hypertension, and one was syphilitic. In each there was a large hæmatoma, and in 2 cases this had subsequently ruptured into the peritoneal cavity. These authors give, however, no report of any histological examination in their cases, and in view of this it is difficult to see how one can exclude the possibility of an aneurysm as the primary lesion. The diagnosis of aneurysm, after rupture has occurred, may be a matter of considerable difficulty, as is illustrated by the first of the cases described in the present article. This resembled in some ways the first case of Marks and Freedlander, and the correct diagnosis was not made until a careful search had revealed the presence of smooth muscle in the wall of the sac.

Dilated thin-walled veins are not infrequently seen on the surface of a subperitoneal fibroid, but again rupture of such a vessel is remarkably rare, though perhaps not quite as rare as one might gather from standard text-books. Ransohoff and Dreyfoos (1921), in a review of the literature, were able to find 19 reported cases, and themselves described 2 more. Professor Ameline (1945) mentions 1 case and gives a vivid description, which accords closely with the writer's experience. He says " J'ai personnellement vu une énorme veine, grosse comme l'auriculaire, *qui saignait en jet* à la surface d'un myome ".

A correct pre-operative diagnosis is unusual, and the recorded cases have been variously diagnosed as twisted ovarian cyst, ruptured ectopic gestation, perforated peptic ulcer, and acute appendicitis.

As regards treatment, Ransohoff and Dreyfoos suggest that in a patient who has lost a lot of blood the wisest course would be to content oneself in the first instance with ligating the vessel above and below the point of rupture. In every recorded case, however, hysterectomy has been performed, with recovery in the majority, and this, combined with blood transfusions, would seem to be the method of choice.

I am indebted to Professor Brockman for allowing me to report these cases; to Professor Davies for examining one of the specimens; and to Dr. Hermitte for examining both specimens and for help with the photography.

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PERITONEAL LOOSE BODIES

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PERITONEAL loose bodies are rarely described. The following case history therefore appears worthy of record.

CASE REPORT

HISTORY.—Michael McN., aged 69, was admitted to the wards at Leith Hospital in the charge of Mr. W. W. Carlow on July 31, 1946, with a history of attacks of low abdominal pain for three years and nausea and constipation for one month.

EXAMINATION.—The patient was found to be an undernourished elderly man with general debility and some recent wasting. A lump was felt in the abdomen, through the thin abdominal wall, to the left of the umbilicus, hard, smooth, and about the size of a hen's egg and slightly movable. A radiograph of the chest showed apical fibrosis and possible calcification in the suprarenal regions. The prostate felt uniformly hard on rectal examination, with no areas of irregularity. There were some glands palpable in the left posterior triangle of the neck. A barium meal and a barium enema were given, both yielding negative results.

TREATMENT.—Laparotomy was considered advisable. Under general anæsthesia on Aug. 15 a left paramedian incision was made centred on the umbilicus. Many fibrous adhesions were found in the neighbourhood of the pylorus, fixing it to the under-surface of the liver. Liver, stomach, transverse colon, and gall-bladder were healthy. On passing a hand inferiorly, the tumour, palpable through the abdominal wall, was detected. It was found to be easily movable, and was pushed up between the stomach and transverse colon. A small incision was made into the anterior layers of the greater omentum. The tumour presented and extruded itself

—a smooth white object, the size of a hen's egg, oval, and slightly flattened on each side. The cavity of the lesser peritoneal sac, whence the loose body had come, was patent and perfectly smooth, with no free fluid in it and no adhesions. The pancreas, palpated through it, was normal. The incision in the greater omentum was sutured and the abdomen closed without drainage. The

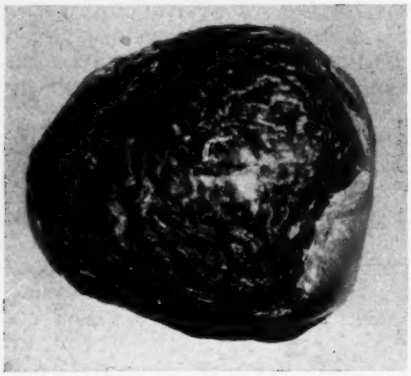


FIG. 358.—Photograph of peritoneal loose body after removal and hemisection, the halves being reunited with wax. The crinkling on the surface produced by the shrinking on drying is visible. (*Natural size.*)

patient made an uneventful recovery from the operation and on discharge stated he was feeling better.

This improvement was not maintained. The patient was admitted to the Southern General Hospital on Sept. 20 and died on Oct. 17. A post-mortem examination by Dr. Wm. Forbes on Oct. 18 showed an adenocarcinoma of the prostate gland with extensive secondaries in lymph-glands and bones.

There was active pulmonary tuberculosis with cavitation of the left apex. The stomach was healthy apart from adhesions of its anterosuperior surface to the under-surface of the liver. Situated in the first part of the duodenum was the stellate scar of a typical healed peptic ulcer and a small diverticulum was present immediately proximal to and slightly above the scar.

The loose body when first seen at delivery from the lesser sac of the peritoneum was smooth, glistening, and white. It was oval in shape, slightly flattened from side to side, and about the size of a hen's egg. Immediately after removal it weighed 67 g. Its surface became

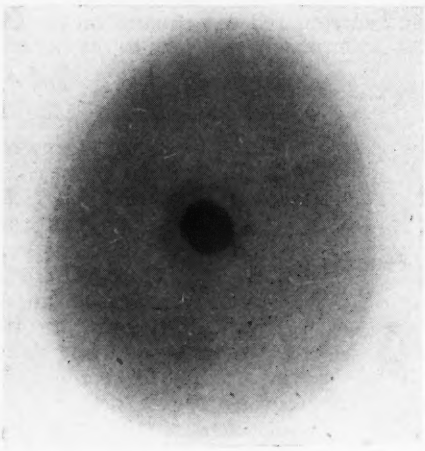
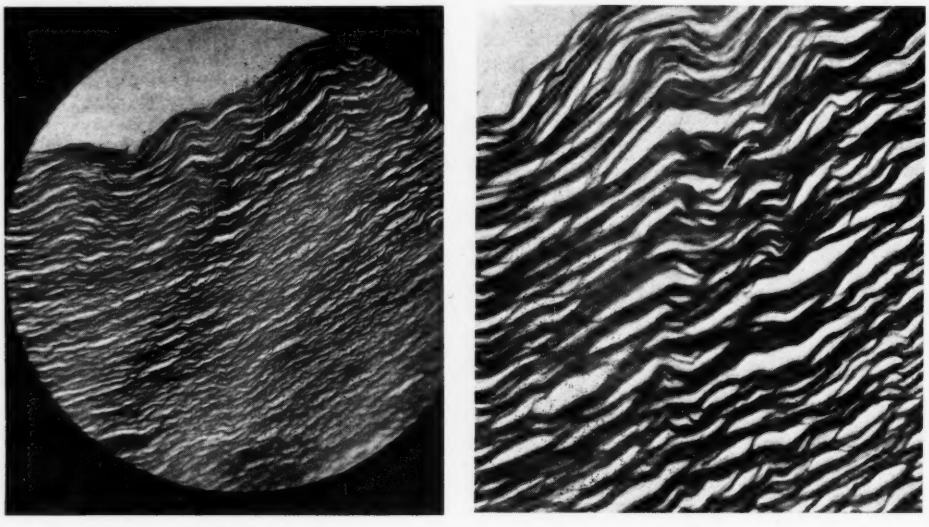


FIG. 359.—Radiograph taken immediately after operation, showing the dense opaque centre with the concentric rings of dense and less dense areas surrounding it.

gradually crinkled and yellowish and the sheen disappeared as it became dry. A week after removal it weighed 29·9 g. and presented the appearances as shown in *Fig.* 358.



A B

FIG. 360.—Sections (A, × 300; B, × 750) showing the structure of the peripheral part of the loose body; laminated circumferential strands of eosinophil, uniformly staining fibrinoid substance, and absence of any cellular structure.

A radiograph revealed a small circular opaque centre in a slightly less dense area inside a narrow dense ring surrounded by a less dense periphery (*Fig.* 359).

On examination at the Royal College of Physicians' Laboratory, Edinburgh, the hard central core was found to consist of calcium phosphate around which were laminated and circumferential strands of an eosinophil and uniformly staining substance, probably fibrinoid, with no evidence of any cellular reaction even on the surface (*Fig.* 360).

DISCUSSION

The appearance of this loose body resembled that of the similar loose bodies in the peritoneum described in the literature. Hunt (1919) described one case and gave an abstract of reports of eleven similar cases. Those of Littré, Shede, and Cruveilhier mentioned by Hunt were smooth round white

A B

FIG. 361.—Photograph showing the two loose bodies in McIntosh's case (A) and the loose body found in a cadaver (B) (*Natural size.*)

bodies lying free in the peritoneum. Johnstone (1928) states that a number of interesting cases were recorded in the *Transactions of the Pathological Society of London* in addition to those quoted by Hunt. " In all, nine specimens of loose body from the peritoneal cavity were exhibited to this society between 1854 and 1860. The first, exhibited by Mr. Shaw, was from a hernial sac, was more or less round, 1½ in. in diameter, and was described as looking like a hard-boiled egg with the shell removed . . . section of it showed a cortex as dense as fibrocartilage, while the centre was cystic and contained fat. Mr. Shaw suggested that a detached appendix epiploica had become coated with successive layers of fibrin from the peritoneal serum and this formed the dense outer covering which he described . . . One of the nine specimens was exhibited by Dr. Hughes Bennett and is described as being as large as a billiard ball."

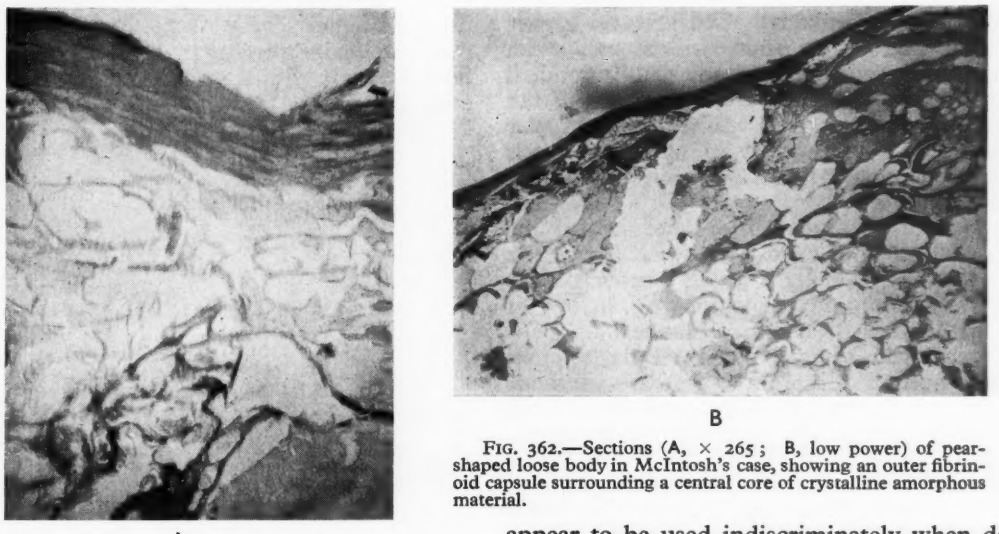
More than one loose body may be present. Laveran, Riedel, and Neri described such cases (Hunt), and Mr. Donald McIntosh (1947) has communicated the following details of another :—

Mrs. A. P., aged 75, was admitted to the wards in the Royal Infirmary, Edinburgh, in the charge of Mr. K. Paterson Brown on Sept. 22, 1946, with twenty-four hours' history of acute abdominal pain. An examination sometime previously had demonstrated the presence of biliary calculi. She was obese and the abdomen was extremely tender. On Sept. 22, under spinal anæsthesia, the abdomen was opened by a right lower paramedian incision. Two small intraperitoneal bodies were found in the pelvis where there was a small amount of turbid free fluid. On exploration the gall-bladder was found to be the subject of chronic inflammation, but was not acutely inflamed. On passing a hand over the liver, however, an abscess cavity was entered and a small amount of pus evacuated. A swab was taken. A drain was brought out under the costal margin and since no other pathological lesion could be found the wound was closed in layers. The patient made a good recovery and went home completely healed on Oct. 8.

The loose bodies were small, about the size of large peas. One was oval and the other pear-shaped with a short stalk. Their appearance is shown in *Fig.* 361.

Histological examination of both (*Figs.* 362, 363) showed the same essential structure as in the first case—a central core of crystalline amorphous material surrounded by a capsule of fibrinoid material. This core consisted chiefly of calcium phosphate with a trace of organic matter.

Aetiology.—The composition of loose bodies in the peritoneum depends on their origin. The fact that the terms ' loose body ' and ' foreign body ' appear to be used indiscriminately when describing free bodies in the peritoneum shows in itself that the aetiology of these bodies is not entirely understood. The term ' foreign body ' implies something which has gained the peritoneal cavity from the outside of the body such as a piece of shrapnel, or has ulcerated through into the peritoneum from the lumen of the gut such as the piece of wood 2 in. (5 cm.) long perforating the ileum, recently described by Read (1946). The term ' loose body ' implies something which has worked free from the lining of the abdomen, resembling the loose bodies found in joints which are the site of lipoma arborescens.



A B

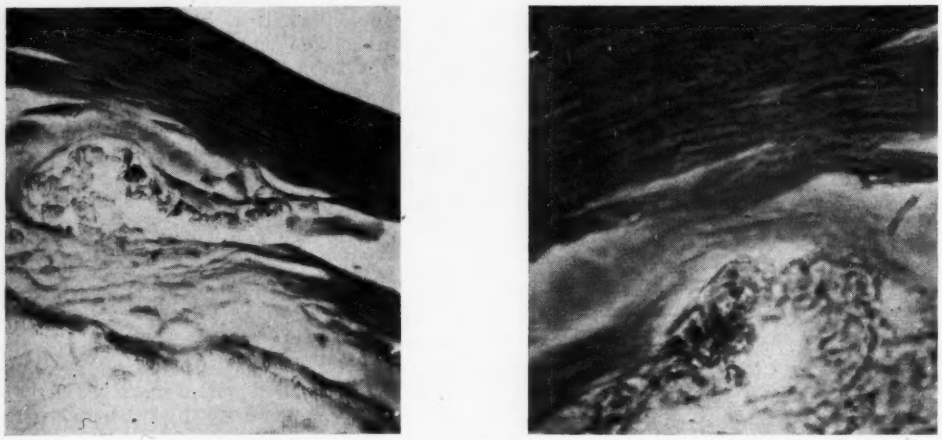
FIG. 362.—Sections (A, × 265; B, low power) of pear-shaped loose body in McIntosh's case, showing an outer fibrinoid capsule surrounding a central core of crystalline amorphous material.

Harrigan (1917) was of the opinion that loose bodies in the peritoneum arose from the appendices epiploicæ. " In 1851 Deville exhibited before the Société Anatomique five foreign bodies which were found in the peritoneal cavity at autopsy. Though

an inspection of the transverse colon revealed an appendix epiploica on the verge of becoming detached, Deville failed to associate this lesion with the formation of the foreign bodies of the peritoneal cavity. He showed that as a result of obesity or an infection, an increased amount of fat is deposited

This was evidently another loose body in the process of being formed.

The structure of the loose body in this cadaver was the same as the ones already described in this paper—a central crystalline core, consisting chiefly of calcium phosphate with a capsule of laminated



A B

FIG. 363.—Sections (A, × 400; B, × 1000) of the oval loose body in McIntosh's case, showing a well-defined outer fibrinoid capsule and a central core of crystalline amorphous material.

in the appendices epiploicæ. This fat undergoes saponification and calcification which causes an increase in weight and which in turn leads to gradual and progressive obliteration or obstruction of the blood-vessels of the pedicle. When the vascular obstruction or obliteration is complete, necrosis occurs and the freed and liberated appendix epiploica then falls into the peritoneal cavity."

Hunt (1919) believed that the necrosis of the pedicle of the appendix epiploica was a possible source of the foreign body. Riedel's cases confirm the same view regarding the aetiology. In one of his cases, with two loose bodies, a number of appendices epiploicæ were hanging by a mere thread from the transverse colon. In Hunt's own case a tumour 4 cm. by 3 cm. by 3 cm. was found free in the pelvis. This proved to be a sac containing degenerated fat, probably an appendix epiploica which had become twisted off from its attachment to the large bowel. The shape of the larger of the two loose bodies in McIntosh's case definitely suggests an appendix epiploica which has become free.

A specimen recently examined in the Anatomy Department, Edinburgh University, tends to confirm the view that some loose bodies at any rate do arise in this way. A small loose body the size of a large pea (*Fig.* 361, B) was found in the pelvis of an elderly male subject. The peritoneum was diffusely studded with minute gritty particles. There were no adhesions, no calcified glands, and no ascitic fluid, and the peritoneal condition was taken to be most probably a healed tuberculous lesion. There were numerous large appendices epiploicæ along the length of the colon. On the upper pelvic colon one of these on the medial side was constricted in the middle, the distal portion appearing ready to drop off (*Fig.* 364). The constricted waist was white and fibrous as contrasted with the yellowish fat of the rest of the appendix. fibrinoid material (*Fig.* 365).—a structure compatible with the origin from an appendix epiploica, the fatty structure of an appendix epiploica having undergone calcification, and the fibrinoid being deposited by the peritoneum.

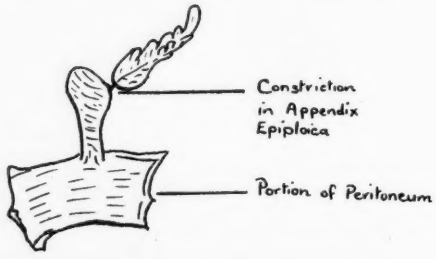


FIG. 364.—Photograph of drawing of an appendix epiploica from a cadaver showing a constricted 'waist', the distal half appearing ready to drop off into the peritoneal cavity.

Loose bodies in the peritoneum may come from other sources than a detached appendix epiploica. In Johnstone's (1928) case, laparotomy was performed for tenderness associated with a small movable mass, opaque to X rays. "Lying perfectly free in the pouch of Douglas, a hard calcareous mass was found, the size and shape of a large Brazil nut, dark green in colour, outer part calcareous, interior consisting of dried-up tissue which crumbled to dust. A portion of the mass was decalcified and a microscopical section made. It was structureless except here and there on the surface little patches of quite clearly recognizable low cubical epithelium closely resembling the germinal epithelium of the ovary . . . Another source to which reference is made by writers is subperitoneal uterine fibroids. Bland-Sutton makes a brief reference to these, and Halliday Croom (1896) refers to Sir James Simpson as having

described instances discovered post mortem . . . Croom records two striking cases of his own. The first was a simple ovarian cyst occupying the pouch of Douglas, the second was a hard tumour the size of a billiard ball in the pouch of Douglas. The contents of the tumour were found to be old blood-clot and Haultain suggested the loose body was really a tubal abortion in which the blood-clot had become coated with fibrin."

In our case, no evidence was found either at operation or at necropsy of twisted appendices epiploicæ. It is difficult to see how a loose body lying in the lesser peritoneal sac, as this one was, could possibly have arisen from such a source. The gall-bladder, the pancreas, and kidneys were examined post mortem and no calculi were found in them. There were no calcified tuberculous glands in the mesentery. The dense adhesions in the pyloro-duodenal region seen at operation, and the scarred duodenum found post mortem, showed that at one time there had been active ulceration and a leak or small perforation into the lesser sac. It seems, therefore, likely that the original cause of the loose body was a nidus of foreign or inflammatory material from the perforation of the duodenal ulcer, passing into the lesser sac. Calcification occurred in this nidus, and then layer upon layer of peritoneal fibrin

FIG. 365.—Section (× 265) of a loose body from a cadaver showing the central crystalline core consisting chiefly of calcium phosphate.

was deposited around the central hard core, the reaction of the peritoneum to a very low grade of irritation. The central hard core was small and the surrounding capsule of fibrin was thick. It is reasonable to suppose that the loose body had been in the peritoneum for a long time, as contrasted with the smaller loose bodies shown in *Fig.* 361 where the capsule was thin. Strictly speaking, then, this was originally a ' foreign body '.

Symptomatology.—A study of the cases described does not reveal any special symptoms pertaining to ' loose bodies ' themselves, though Harrigan quotes Cruveilhier as pointing out their liability to cause peritonitis. In Littré's case the loose body was found during the dissection of a cadaver. In Virchow's case the patient had died of peritonitis, cause unspecified. In Shede's case the patient had symptoms of ileus. Cruveilhier's case had died of an unknown cause; Laveran's case had died of chronic dysentery. In Riedel's cases the symptoms were those of gall-stone colic (2), appendicitis (1), and peritonitis, the loose body being found incidentally. In Hunt's case the patient was very obese and had had six operations for appendicitis, uterine prolapse, and post-operative hernia. The loose body was found in the pelvis during the course of a repair operation for a large post-operative ventral hernia.

In our case, the loose body was found in the course of a laparotomy for vague abdominal symptoms and loss of weight. It was felt through the abdominal wall, and diagnosed tentatively as a tumour. The patient had an adenocarcinoma of the prostate gland with widespread metastases in lymph-glands and bone, and he also had active tuberculosis at the left apex. Both these diseases singly could have accounted for his dyspepsia. There was the evidence of old ulceration of his duodenum which must have given him considerable symptoms at one time, though the condition was found to be quiescent at post-mortem examination. The loose body, lying in the lesser peritoneal sac, showed no evidence of any inflammatory reaction around it, and even on its surface no cellular reaction could be demonstrated. It had evidently caused no disturbance per se.

In McIntosh's case the two loose bodies were found in the pelvis during the course of an operation for a subphrenic abscess. The pelvis appears to be the common site for loose bodies, due probably, as Johnstone points out, to the action of gravity.

Conclusions.—Loose bodies in the peritoneum are of variable size and number, and they arise in different ways. The reaction of the peritoneum to them consists in depositing layers of fibrinoid material, the loose body growing in size the longer it remains. They give rise to no definite symptoms of their own, and are found incidently at laparotomy or in the cadaver.

SYMMARY

1. A case of loose body lying in the lesser sac of the peritoneum is described.

2. The structure, aetiology, and symptomatology of loose bodies in the peritoneum is discussed.

We are grateful to Professor J. C. Brash for the use of the facilities of the Anatomy Department, Edinburgh University, and for constructive criticism in the preparation of this paper. We must thank Dr. Wm. Hunter, of the Southern General Hospital, Edinburgh, for progress notes and post-mortem findings; and we are indebted to Mr. John Borthwick, of the Anatomy Department, Edinburgh University, for the photographs shown in *Figs.* 358 and 364 and to Mr. S. C. Hay, of the Royal College of Physicians' Laboratory, for making and photographing the histological slides shown in *Figs.* 360, 362, 363, and 365, and the photograph in *Fig.* 361.

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STRANGULATED OBTURATOR HERNIA

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STRANGULATION in an obturator hernia presents, in most cases, a well-defined clinical picture; but there is a tendency to consider it a rare and undiagnosable cause of intestinal obstruction. Perusal of the literature shows that it is much more common than is usually thought, over 400 cases having been recorded. In the majority of cases the condition is discovered only after laparotomy; Watson (1938) found that a pre-operative diagnosis was made in only 53 out of 228 cases. Because it is associated with a high mortality (37–71 per cent—Watson, 1938), which can only be reduced by early recognition of this condition, we feel prompted to record the following two cases which were admitted to the same hospital within ten days of each other. Both presented classically and a pre-operative diagnosis was made in each. Pre-operative recognition of the condition is paramount to reduction of mortality, as a better planning of the abdominal incision is possible, with easier access to the sac and a minimum of trauma in an aged, often wasted, dehydrated, and bronchitic patient.

FIG. 366.—Sac removed from *Case* 1.

CASE REPORTS

Case 1.—A. B., female aged 82, married with 12 children, admitted to St. James's Hospital, Balham, on Aug. 15, 1946, complaining of abdominal pain and vomiting.

HISTORY.—Seven hours before admission she was suddenly seized with severe colicky lower abdominal pain, which was associated with acute pain referred down the front of the left thigh to the knee. Shortly afterwards she commenced vomiting, at first food, later bile-stained fluid. These symptoms persisted without remission. The bowels had been confined for two days and no flatus passed since the onset of pain. Prior to the onset she had been lifting heavy furniture and hanging pictures.

Past History.—During the last six years she had been steadily losing weight, and she stated that she had suffered from severe constipation for many years with occasional rectal bleeding and prolapsing piles. Nine months ago she had a similar attack which was treated by enemata at home and subsided in 3–4 days.

ON EXAMINATION.—A pale, frail, wasted woman with a dry furred tongue. Temperature 98·4° F. Pulse 96, with good volume. The heart-sounds were normal. B.P. 188/110. The lungs were normal.

The abdomen was not distended, but there was tenderness and guarding in the lower quadrants. She was having obvious spasms during which the peristaltic sounds were somewhat turbulent. Immediately to the lateral side of the left adductor longus tendon in the upper and inner angle of Scarpa's triangle was a small, tender, somewhat ill-defined lump about the size of a walnut, with no impulse on coughing. A finger could be pressed down firmly on the pubic ramus above it without pain, this excluding a femoral hernia. The other hernial orifices were normal and the obturator test—pain on flexion and internal rotation of the hip—was negative.

A soft tense tender swelling on the left anterolateral pelvic wall was felt on rectal examination. The opening of the right obturator canal was easily felt. Intero-external piles were noted.

A pre-operative diagnosis of strangulated left obturator hernia was made.

AT OPERATION.—Spinal anæsthesia (2 c.c. heavy nupercaine). After catheterization a lower midline laparotomy was performed and the patient placed in the Trendelenburg position. There was a small amount of blood-stained peritoneal fluid. Collapsed and distended loops of small bowel were found, and in following a distended one into the pelvis it became suddenly delivered into the wound, and on its antimesenteric border was seen an area of œdema congestion suggestive of a strangulation of the Richter type. This area was considered viable.

Further exploration revealed a large left obturator hernial sac with œdema and ecchymosis of the wall suggestive of recent strangulation within it (*Fig.* 366). The other hernial orifices were normal. The sac was inverted and after freeing it from the bladder was removed and peritoneum sutured. No further attempt at radical cure was made. The wound was closed with through-and-through sutures of floss silk. After operation the lump in Scarpa's triangle was no longer present.

Post-operative intravenous saline and continuous gastric suction were employed for 24 hours and the patient made an uninterrupted recovery, being discharged on Aug. 29, 14 days after admission.

Case 2.—E. H., female aged 66, married, with two adult daughters. Admitted Aug. 27, 1946.

HISTORY.—Three days previously while performing her ordinary housework she had an attack of right-sided abdominal pain and vomited. The pain became colicky and spasmodic, and 24 hours later commenced to radiate down the front of her right thigh to her knee. Her bowels had not been opened and she had passed no flatus since the onset of the pain. The previous evening she had been given an enema without result. Pain and vomiting persisted.

Past History.—Five months previously she had had a similar attack which was not so severe and had subsided without treatment after 36 hours.

ON EXAMINATION.—She was extremely thin and looked older than 66. The tongue was furred and dry.

Abdomen: There was slight distension but no increase of peristaltic sounds. No rigidity was present and no mass palpable. While examining the hernial orifices, tenderness was elicited over the upper inner angle of Scarpa's triangle just lateral to adductor longus muscle, and there was some fullness in the same region. The obturator test was negative, but movements of the right hip-joint were limited in internal and external rotation, abduction, and adduction.

Per rectum a small firm mass was palpable in the right lateral pelvic wall.

A diagnosis of strangulated obturator hernia was made and the patient prepared for operation.

OPERATION.—Anæsthetic: Local infiltration of incision and field block with 1–2000 anethaine, pentothal 1 g., and oxygen.

Through a low midline incision, the bowel was found to be distended and congested. A loop of small bowel was found passing through the right broad ligament and carrying the middle third of the right Fallopian tube into the right obturator canal. The bowel was released after stretching the obturator foramen with the tip of the index finger and two rings of constriction of doubtful viability 2 ft. from the cæcum were oversewn. Together with the right ovary, Fallopian tube, and part of the broad ligament, the sac of the hernia, after inversion, was removed (*Fig.* 367). The wound was closed in layers. The patient made an uneventful recovery and was discharged on Sept. 9, 1946.

COMMENTS

It is not the purpose of this article to describe the anatomy of the obturator canal and there is little to add to the classical description by Wakeley (1939). We also realize that only two cases are recorded, but they show a number of striking points which have not been stressed in previous writings.

Diagnosis.—The combination of acute intestinal obstruction with pain referred down the front and inner side of the thigh to the knee (Howship-Romberg sign) in an elderly wasted woman suggests strangulation of bowel in an obturator hernia as a likely cause.

In confirming the diagnosis the following signs should be sought:—

1. Most constant is the presence of a tender swelling palpable on the lateral pelvic wall by rectal or vaginal digital examination.

2. Tenderness within Scarpa's triangle which may sometimes be associated with a fullness or even a well-defined lump. This is differentiated from a femoral hernia by the fact that the fingers may be pressed down on to the pubic ramus above the lump without discomfort.

3. The limb is usually maintained in a semiflexed position and hip movements are limited by pain.

Trelat (1872), quoted by Watson, was one of the first to observe and record the presence of emaciation in cases of obturator hernia. Both of our patients were abnormally thin, with a minimum of fatty tissue as well as muscle wasting.

Pique and Poirier (1891) considered that because of the narrowness of the obturator canal, herniæ were rarely palpable. Both of these cases showed some abnormality in Scarpa's triangle. The first had a palpable lump and the second a fullness.

Van Meurs (1945) reported a case of strangulation of ovary and Fallopian tube in an obturator hernia. In our second case the right Fallopian tube was carried into the sac with the small bowel. From the anatomical disposition of the tube at the entrance to the sac one would expect this to be a more common finding than a search through the literature reveals.

Treatment.—A pre-operative diagnosis having been made, the bladder is emptied by catheterization and an incision giving rapid and full access to the lesion carried out. In view of the poor general condition and advanced years of these patients, speed is essential. Local anæsthesia with cyclopropane or pentothal is satisfactory, although the relaxation afforded by spinal anæsthesia is a distinct advantage. There is no doubt that there is an increased risk of chest complications in the latter, but as the manipulations are confined to the lower abdomen a relatively low level of anæsthesia is sufficient, and good function of the lower intercostal muscles can be retained. We consider that deep inhalation anæsthesia is contra-indicated for obvious reasons.

There is no doubt that a lower midline incision gives an excellent exposure, and opening and closing the abdomen can be performed with great rapidity. The Trendelenberg's position is essential. If a strangulated obturator hernia has been considered pre-operatively a direct attack can be made on the sac without the manipulations required in finding the junction of collapsed and distended loops.

FIG. 367.—Showing sac, Fallopian tube, and ovary removed from *Case* 2.

Constriction at the neck of the sac is seldom tight, so that gentle stretching with the finger is usually all that is required to deliver the strangulated loop safely into the abdomen; in fact, the reduction is frequently possible without this manœuvre, as occurred in *Case I*. Furthermore it is evident that spontaneous reduction without strangulation does occur, as evidenced by the recurrent attacks of colic so common in the history. Van Swalenburg (1913) records a case with twenty-six years of such attacks without complete strangulation.

It has been recorded that strangulation is almost always of the Richter type and seldom is gut resection necessary. A partial resection of the bowel wall or the turning in of an area of doubtful viability is all that is required in most cases.

Whether or not the sac itself should be removed or some form of repair carried out, depends largely upon the general condition of the patient. We feel that this should be limited to the minimum operative procedure and that removal of the sac only should be adequate. It is as well to remember in doing this the intimate relation borne by the bladder to the neck of the sac. If the Fallopian tube and ovary are involved, removal of them with the sac presents no difficulty.

Post-operative treatment requires no special comment except that we consider that early mobilization of the patient is essential in the prevention of chest complications and pulmonary embolism.

SUMMARY

1. Two cases of strangulated obturator hernia are recorded stressing the importance of pre-operative diagnosis.

2. A brief description of the diagnosis and operative treatment is given.

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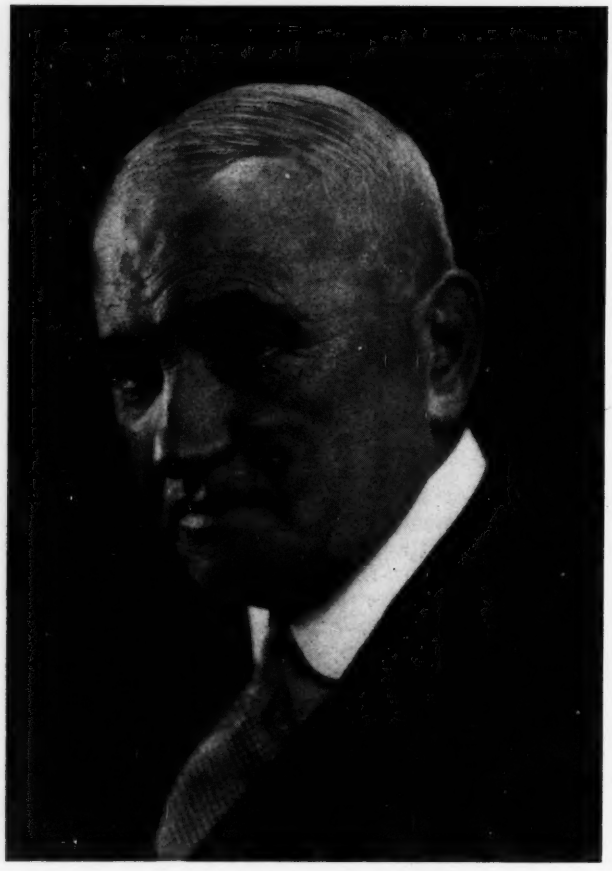
In Memoriam

W. ERNEST MILES, T.D., F.R.C.S., F.R.C.S.I. (Hon.), F.A.C.S. (Hon.)

(1869—1947)

THE death of Ernest Miles has removed one whose name was known wherever surgery is practised. Trained at St. Bartholomew's Hospital, he approached surgery by the avenue of the dissecting room. The province of rectal surgery early attracted him, and he became house surgeon to the famous St. Mark's Hospital, and within a few years was appointed to the surgical staff of the Gordon Hospital for Diseases of the Rectum. He attained the senior honorary staff of the Royal Cancer Hospital as far back as 1903.



W. ERNEST MILES,
T.D., F.R.C.S., F.R.C.S.I. (Hon.), F.A.C.S. (Hon.)
1869—1947

Much of his early training in rectal surgery he owed to David Goodsall, to whose memory he dedicated his own book on *Rectal Surgery* in 1939, and with whom he had collaborated in a two-volume work on *Diseases of the Rectum and Anus* forty years before.

Miles did much to clarify the pathological anatomy of hæmorrhoids and their operative treatment by emphasizing the distribution of the terminal branches of the superior hæmorrhoidal vessels. His 'pecten band' may not have satisfied the critical scrutiny of all proctologists, but his outstanding success in the treatment of fistula was due to his enormous experience of this malady. Possibly the complexity of his classification of fistulæ provided an indirect stimulus to the important anatomical studies of Milligan and Naunton Morgan, who revivified the work of that great anatomist and friend of some of the older generation of surgeons, Peter Thompson, at the end of the last century.

It was, however, in connexion with the operation of abdomino-perineal excision of the rectum that the name of Miles will be honoured by posterity. He planned the outlines of the operation in 1906 and began to practise it the following year.

A master surgeon, a brilliant and dexterous craftsman, wasting no time, he had little patience with the tortoise technique so much in vogue to-day. He reduced the time of the abdomino-perineal excision gradually from one and a half hours to under thirty minutes.

This great 'surgical pathfinder' was happily spared to see the day when the operation, of which he was the stalwart pioneer and which he had so

long championed with unswerving conviction and dauntless courage from almost the dawn of the century, become the recognized practice, rendered safe to-day by modern anæsthesia, chemotherapy, and other ancillary methods which he lacked forty years ago.

The Irish blood of his maternal ancestors flowed in his veins, and some of his forebears had served with Wellington in the Peninsula. It was, therefore, not surprising that with this family tradition, with so many personal attributes that make for leadership, with his passion for the horse and horsemanship, and his love of the copses, thickets, and the green sward, this 'Laughing Cavalier' should have been a Territorial officer years before the outbreak of the first Armageddon.

In that war he filled many posts, from operating surgeon in an abdominal centre behind Ypres, to A.D.M.S. of a Territorial Division, from head of the surgical department of a Base hospital in France to Consulting Surgeon in the Etaples area of the Pas de Calais.

The character and personality, as well as the surgical achievements, of Miles and his colleague, Sir Charles Ryall, raised the prestige of the Royal Cancer Hospital and bequeathed to it a tradition ably maintained by their younger henchmen and acolytes. With the help of men like Captain Corfield and James Dewar he made the Gordon Hospital a temple of healing worthy of the surgeons and the surgery performed within its walls.

He loved his fellow-men; he never said an unkind word of anyone; with his happy nature he lived to the Horatian prescription:—

Ut quocunque loco fueris, vixisse libenter
Tu dicas.

The zest of life and laughter lasted long past the three-score years and ten of man's allotted span.

Academic honours had come to this great international figure, not only from his own country, but from Ireland, the United States of America, France, and Greece. As he looked back over the long years of his life, realizing the deep admiration and affection of all his surgical brethren, he might well have exclaimed in the dying words of the great Master of Balliol, Benjamin Jowett: "Thank God for my life!" But surgeons everywhere and the world's patients thank God for the gift of Ernest Miles.

FRÉDÉRIC FRANÇOIS BURGHARD, C.B.

(1864—1947)

THE passing of F. F. Burghard on October 31, 1947, removes another of the few surgeons who were associated with Lister. He was educated at Christ's College, Finchley, and from there he went to Guy's Hospital, where he had a very distinguished record, for besides obtaining a large number of prizes he played for the Guy's XV, the United Hospitals' XV, and won a trial cap for England. He obtained his M.D., M.S. (Lond.), gaining the gold medal in Surgery, and took his F.R.C.S. (Eng.) when he was 23 years of age. After being Surgical Registrar at Guy's for some years he was appointed Assistant Surgeon at King's College Hospital at the age of 26. He became associated with Lister and Watson-Cheyne and worked with both these surgeons until they retired from practice.

Burghard served as Colonel, A.M.S., in the capacity of a Consultant Surgeon, B.E.F., in the European War, 1914–16; he was mentioned in dispatches and was created C.B. He returned from France in 1916 because of the illness of his wife, who was suffering from an inoperable cancer. He served on the Council of the Royal College of Surgeons from 1915 to 1923 and on the Court of Examiners from 1916 to 1923, and was a member of the Senate of the University of London. He served on the Editorial Board of this JOURNAL from 1913 to 1924.

Burghard was an excellent lecturer and a fluent writer, and his extensive knowledge of modern languages enabled him to translate many French and German books on Surgery into English. As an operator he was superb; being ambidextrous he could operate as well with his left hand as with

FRÉDÉRIC FRANÇOIS BURGHARD, C.B.
(1864—1947)

his right. He was a keen sportsman and surpassed his students in tennis and swimming.

He retired from practice before he was 60 and enjoyed nearly twenty-five years' retirement near Burton-on-Trent. In the early years of this period he led a very active life; he entered into the affairs of his two neighbouring villages. A popular Chairman of many Committees and a judge at many 'Shows'. His interest in the District Nursing Association was keen and practical.

He was a good shot and a good horseman. His favourite hobbies were gardening and carpentry, and he excelled in both of them.

He planned and made a beautiful garden which he delighted to share with his friends; roses and rock gardening were, perhaps, his chief interests, but he had a great love for flowering shrubs and herbaceous borders.

His surgical instincts never left him, for he would sew up the badly torn lip of a favourite spaniel who had had a spirited dispute with a neighbour, or, plucking a few feathers from the neck of one of his wife's chickens, would open and empty out a 'sour crop', put in a few stitches, and rejoice to see the bird none the worse next day!

A man of simple habits, he endeared himself to many. It was a great grief to him that the coming of the Second World War and the calling up of his staff forced him to leave his house and friends and move to Cambridge, where he died.

SHORT NOTES OF RARE OR OBSCURE CASES

MEDULLARY CARCINOMA IN AN AXILLARY BREAST

By Professor A. T. ANDREASEN, Calcutta

The case reported here is of interest because a record is made of the occurrence of a carcinoma in a fully-developed axillary breast, and because of the examination of the anatomical connexions of the abnormally placed breast made at operation.

CASE REPORT

The patient, a Hindu, of Cuttack district, Orissa, aged about 40, came complaining of an abscess of the left breast. She had a family of six children, all alive and well, the youngest being about 15 years old.

On Examination.—She was a well-preserved woman. There were two normally placed breasts which, apart from a certain amount of mastitis, were free from any tumour. In the left axilla, arising from the anterior fold, was a large fully-developed breast containing a massive, hard tumour, infiltrating the whole of the breast, but not fixed to the muscle (*Fig.* 368). The skin was adherent to the tumour generally, and in two places red and shiny, where degeneration had taken place.

Fig. 368.—The patient, showing the left anterior thoracic breast with the axillary breast. The dark area at six o'clock on the axillary breast is the nipple. Directly above the nipple is one area of cystic degeneration.

The *history* was of a normally functioning third breast, at which each of her six shildren had been fed on occasions. Two months ago, she had noticed a hard, slightly painful, lump in the region of the inner and lower quadrant. This had rapidly extended until it now filled the whole breast. There was still relatively little pain, but great discomfort from the weight of the tumour dragging the organ down. The two red areas of degeneration had only come up a week previously.

Physical examination showed a large hard irregular swelling occupying the whole of the abnormally placed breast. The tumour invaded all tissues of the breast including skin and superficial fascia, but was not adherent deeply. No palpable glands could be made out clinically. The right axilla contained no rudiment of a breast. The anterior thoracic breasts were clinically normal and comfortable.

The patient was only willing for operation to remove the affected breast, but no other tissue; this was undertaken five days later under open ether anæsthesia.

Operation.—With the arm well abducted the incision was commenced at the junction of the medial and middle thirds of the clavicle, carried down and outwards between the left thoracic and axillary breasts, over the anterior axillary fold, up behind the breast just inside the posterior axillary fold, to the floor of the axilla. Here the knife was turned out to meet the first part of the incision just below the clavicle. The breast with all the fat and fascia covering the pectoral fold and floor of the axilla was easily raised. Grossly no sign of penetration of the fascial layer could be found. The mass of tissue thus raised was drawn up over the arm and the great pectoral reflected from its humeral insertion, leaving sufficient for re-suture later. Dissection now continued from the apex of the space below the clavicle down to the minor pectoral. This muscle was detached from the coracoid and from its origins. The whole mass of fascia and glands with the muscle was now swept down towards the breast mass, thus clearing everything from the anterior thoracic region. Dissection of the fascia and glands over the latissimus dorsi, subscapularis, and serratus anterior, was now quite easy.

The blood-supply of the extra breast arose from a very large branch of the lateral thoracic artery, taking origin close to the acromiothoracic artery, and from a number of large branches of the lateral cutaneous arteries of the third, fourth, and fifth intercostal spaces.

A very obvious chain of small soft glands lay along the vein accompanying the mammary branch of the lateral thoracic artery and disappeared into the general mass of muscle sheath and fascia under the small pectoral.

The axilla having been cleared completely and the mass removed, the great pectoral was re-sutured in position and the skin incision closed, drainage being made through a separate stab wound in the posterior axillary fold.

The patient recovered well, the wound healing *per primam*. She was discharged with full arm movements on the fifteenth day and has not been seen since. Follow-up of cases is almost impossible amongst the peasantry of India.

THE SPECIMEN.—Fresh macroscopical section showed a mass of growth, partially encapsulated on the deeper aspects but irregularly infiltrating the tissues superficially. The growth was soft and crumbly in places but quite hard elsewhere. Below the nipple the section passes through an area of cystic degeneration involving the skin.

Microscopical section showed masses of spheroidal cells with irregular deeply-staining nuclei and intersections of fibrous tissue.

DISCUSSION

No account could be found in the available surgical and anatomical literature of the dissection of a fully-developed axillary breast and its vascular, lymphatic, and fascial connexions. The principles of an operation for cancer do not permit sufficient dissection to study anatomical details. However, the limit set upon the operative plan by the patient's refusal to accept radical excision did permit some view of these anatomical features at the time.

The breast hung mainly from the anterior axillary fold, but its vascular and fascial connexions suggest that lymph drained from it directly to the glands around the acromiothoracic axis. Thus metastases would be placed high up in the apex of the axilla early in the disease.

The fact that no gland removed with this breast showed metastases means very little. The size of the primary alone is cause for fear that glands at the thoracic inlet or deeper may have already been metastasized.

LARGE INTRASCROTAL MYXOFIBROMA

BY HERBERT ROGERS

PATHOLOGIST TO HILLINGDON COUNTY HOSPITAL

INTRASCROTAL tumours other than those of the testis are relatively rare. Reviews of the literature on tumours of the spermatic cord, epididymis, and testicular tunics by Hinman and Gibson (1924) and by Thompson (1936) show that considerable numbers have been reported from time to time. In more recent reports malignant tumours of the epididymis are discussed by Crabtree (1943), and multiple fibromata of the tunica vaginalis by Bodner (1946), Goodwin (1946), and Goodwin and Vermooten (1946). The case presented in this report is noteworthy on account of the size of the tumour in the right scrotal sac; a similar but smaller tumour being present in the left sac.

FIG. 369.—Intrascrotal myxofibroma. The testis is shown on the left.

The exact site of origin was difficult to determine, but the testis and epididymis could be identified in both instances. It is not certain whether these tumours arose from the tunica vaginalis or from the spermatic cord. This difficulty is noted by Thompson in his review.

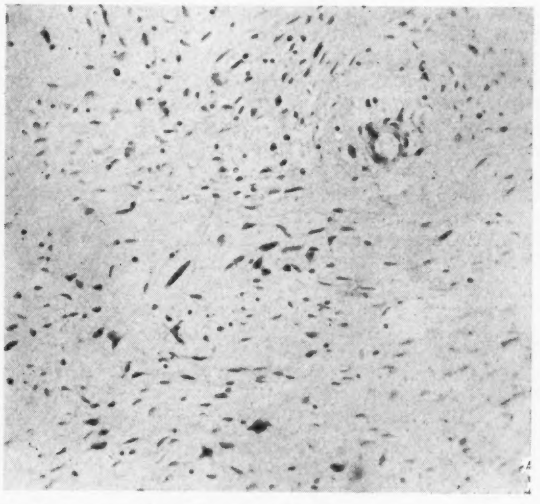


FIG. 370.—Myxofibroma of spermatic cord. (× 120.)

Fibromata of the tunica vaginalis are commonly multiple and relatively small; the majority are regarded as having a chronic inflammatory basis. Lipomata appear to be the most common tumours of the spermatic cord and some tend to reach a large size. Fibromata are only one-third as frequent, but in one case the tumour weighed 18 kilos.

True myxomata are rare in this situation.

CASE REPORT

J. L., a man aged 37 years, was admitted to hospital dying from bronchopneumonia. The scrotum was noted to be very large and his wife stated that the patient had noticed a swelling for the past four years.

Post-mortem examination showed that death was due to bilateral bronchopneumonia with cardiac hypertrophy of primary hypertensive type. Exploration of the scrotum revealed a large, firm, fibrous tumour in the right scrotal sac and a similar but smaller tumour in the left sac. The larger tumour weighed 6½ lb. (3·12 kg.) and the diameter measured 8½ in. (21·6 cm.). The cut surface showed a semitranslucent vesiculated appearance typical of a myxofibroma (*Fig.* 369).

The testis was readily identified at one side of the growth and a thin band of tissue adjacent proved to be the epididymis. The tumour appeared to arise immediately behind the epididymis. The mass in the left scrotal sac had exactly the same anatomical relationship and was identical in structure.

Histological examination of a number of blocks of tissue from this tumour showed the structure to be a comparatively acellular myxofibroma (*Fig.* 370). Delicate bundles of fibrous tissue with myxomatous areas and small thin-walled blood-vessels were found in all the sections. In a few instances there were small collections of lymphocytes in relation to the vessels.

No fat was demonstrable in specially stained sections. The histological diagnosis is that of a benign myxofibroma.

I am indebted to Dr. W. Arklay Steel, Medical Director of the Hospital, for permission to publish this report; and to Mr. E. A. R. Banks for the photograph and photomicrograph.

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FOREIGN BODY IN THE URINARY BLADDER: AN UNUSUAL CASE

BY A. C. BREWER AND R. MARCUS
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THE medical literature from 1880 to 1946 contains reports of no less than 566 foreign bodies in the bladder. The following case seems of sufficient rarity and interest to add to this formidable list.

CASE REPORT

A spinster, aged 46, was referred to the Gynæcological Department with a provisional diagnosis of fibroids. Her pelvic organs were found to be normal. A large and hard mass was felt on vaginal examination situated anteriorly. This was thought to be a bony tumour arising from the pelvic bones. A radiograph was taken and showed a large foreign body in the region of the bladder (*Fig.* 371). When seen by us, symptoms of a marked cystitis were present. For the past few weeks hæmaturia had occurred at the end of micturition. The large foreign body reported in the radiograph could not be felt through the abdomen, but was very easily palpable on both vaginal and rectal examination. Cystoscopy showed what appeared to be a self-propelled pencil surrounded by a large phosphatic calculus. Removal through the urethra did not appear to be practical. The stone and its enclosed foreign body were therefore removed by suprapubic cystotomy. Examination showed a 'Red Dwarf' stylo fountain-pen surrounded by the calculus (*Fig.* 372).

FIG. 371.—Radiograph showing the foreign body in the bladder region.

COMMENT

A primary stone in the female bladder is unusual, and its presence may well be due to an underlying foreign body. The diagnosis may only be made on section, when the foreign body is found forming the nucleus (Dukes, 1936).

Many strange foreign bodies have been found in the bladder. Winsbury-White reports lead pencils, slate pencils, knitting needles, nails, hairpins, button-hooks, feathers, paint brushes, kidney

FIG. 372.—The fountain-pen with the surrounding calculus. (+ ⅔.)

beans, watch chains, leather shoe strings, straw, chewing gum, chalk, slippery elm, paraffin, tallow, bougies, and catheters. To this list may be added a perfume bottle in a man's bladder (Duncan, 1927); hog's penis in the female urethra (Gill, 1933); condom forming the nucleus of a vesicle calculus (Badenoch and Campbell, 1937); a toothbrush handle (Hime, 1874); decapitated snake (Geyerman, 1937); squirrel's tail (Gill, 1933); a thermometer (Aspinall, 1931); a snail (Harris, 1931); candiru, which is a species of fish that penetrates the urethra

and enters the bladder (Roche, 1945); a sponge (Mauterer, 1936); a wasp (Lins, 1945); and many others, including a paraffinoma following injection for hernia, with ulceration into the bladder.

By far the largest number of foreign bodies are those introduced by the patient to procure abortion or as a concomitant to masturbation. Havelock Ellis states: "The use or rather abuse of the ordinary implements of daily life in obtaining auto-gratification among the ordinary population in civilized lands has reached an extraordinary degree of extent and variety". This is substantiated by the list of articles removed and the ingenuity required of the surgeon for their removal.

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AN ATYPICAL LYMPHADENOID GOITRE ENCIRCLING THE TRACHEA AND LARYNX AND CAUSING PERIODIC ATTACKS OF APHONIA

BY MICHAEL C. OLDFIELD, M.B.E.

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THIS case is of interest from both a pathological and clinical aspect. The patient was a singer who suffered from intermittent attacks of aphonia caused by a non-malignant goitre which surrounded the trachea and larynx. After partial thyroidectomy, histological examination of the goitre showed it to have features of both lymphadenoid goitre and Riedel's thyroiditis. It is thought that this gland may have been removed during its transition from lymphadenoid goitre (Hashimoto) to Riedel's struma. Sir Robert Muir originally held the view that Riedel's thyroiditis was the later stage of lymphadenoid goitre. Within recent years there has been a tendency to consider these two conditions as separate pathological and clinical entities.

CASE REPORT

Miss D. A., a singer aged 43 years, first noticed about two years ago that she had difficulty in "getting certain notes". Periodically since this time she had lost her voice for as long as a week. About twenty of these attacks had occurred during the last two years. She had noticed "pressure on the gullet" and some difficulty in swallowing. When bending her head forward she sometimes had difficulty in getting her breath. She had suffered also from a cough and had lost a stone in weight in two years.

ON EXAMINATION.—The patient was a highly-strung type of individual. She had a visible symmetrical goitre of moderate size which was firm and smooth on palpation. There were no signs of thyrotoxicosis or pressure upon nerves or vessels in the vicinity.

A plain radiograph of the neck (*Fig.* 373) showed a sharp forward angulation of the larynx in the region of the thyroid and cricoid cartilages: the upper part of the trachea was also dislocated forward and slightly to the right.

On laryngoscopy Mr. T. McM. Boyle found no evidence of recurrent laryngeal palsy.

OPERATION (Dec. 5, 1946).—Partial thyroidectomy was performed under intratracheal anæsthesia at the Dewsbury and District Infirmary.

The gland was found to be pale, firm, and partially adherent to the infrahyoid muscles. The thyroid was otherwise well defined and was found to embrace completely the lower part of the larynx and upper part of the trachea. A large prolongation from the inner and posterior aspect of the right lateral lobe passed between the pharynx and œsophagus behind and the cricoid

FIG. 373.—Radiograph showing anterior dislocation of larynx and trachea caused by the retrotracheal process of the goitre.

cartilage and trachea in front, and came in contact with the sheath over the posterior and inner aspect of the left lateral lobe. The retrotracheal prolongation was easily withdrawn and four-fifths of the gland was removed.

PROGRESS.—The patient went home nine days after operation, and when seen two months later she stated that her voice had returned to normal.

PATHOLOGICAL REPORT (Dec. 12, 1946).—Professor M. J. Stewart reported on the thyroid: To the naked eye this much enlarged thyroid presents a remarkably lobulated appearance on the surface, the lobules ranging from 2 or 3 mm. up to 2 cm. in diameter. The whole gland is affected, though the general outline is somewhat asymmetrical. The right lobe, for example, measures 7·6 cm. in length from above downwards, the left 6·5 cm., while the transverse diameters are respectively 3·5 and 4·5 cm. The appearances are suggestive of chronic thyroiditis (either Riedel or Hashimoto). It would seem that the lateral lobes have completely encircled the trachea behind.

The lesion is a very remarkable thyroiditis, the changes being mainly those of lymphadenoid goitre in a moderately advanced stage. Not only are there numerous lymphoid follicles intermingled with the thyroid tissue, but there is also great diffuse infiltration of the stroma by lymphocytes and plasma cells. The glandular tissue still survives in large amount, but the acini are mainly small and often contain no colloid. Where colloid is present it is in the form of small deeply-staining masses. There are, however, certain areas where the acinar structure still appears fairly normal. Elsewhere the epithelial islets are non-luminated, as is often seen in Riedel's thyroiditis. Indeed, the characters here, while mainly those of lymphadenoid goitre (Hashimoto), are in some respects those of Riedel's struma. This sort of case, indeed, suggests the view that Riedel's struma may be a later phase of lymphadenoid goitre.

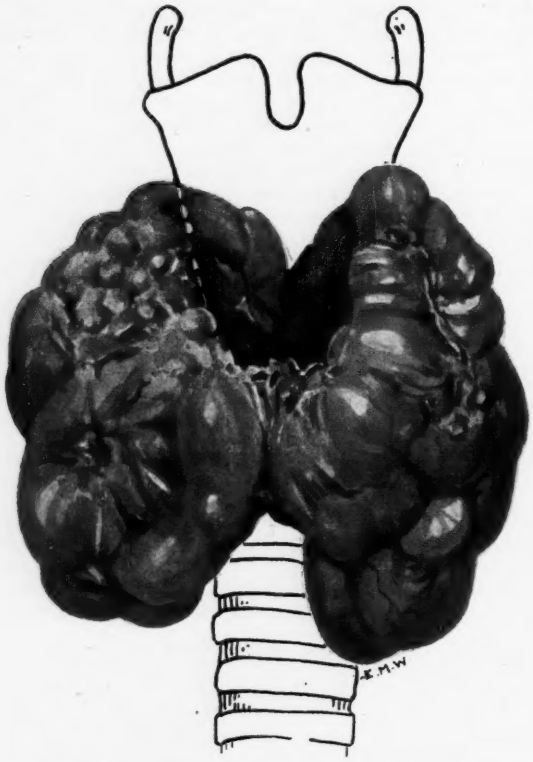

FIG. 374.—Anterior aspect of the goitre, showing how it embraced the larynx and trachea.

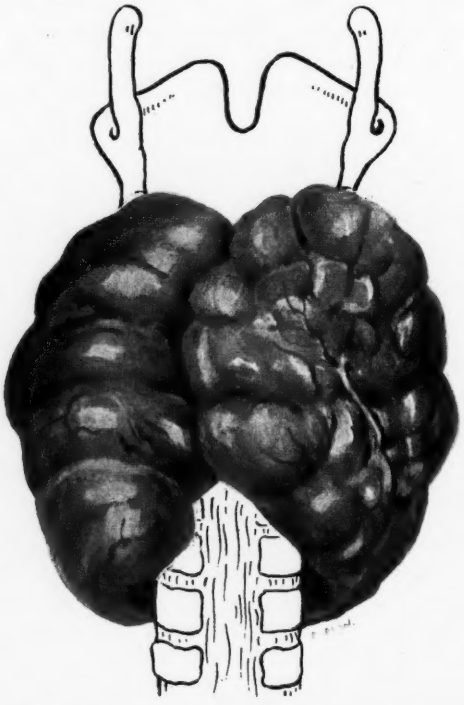

FIG. 375.—The posterior aspect of the goitre, showing how a prolongation of the right lateral lobe passed behind the trachea and larynx and came into contact with the left lateral lobe.

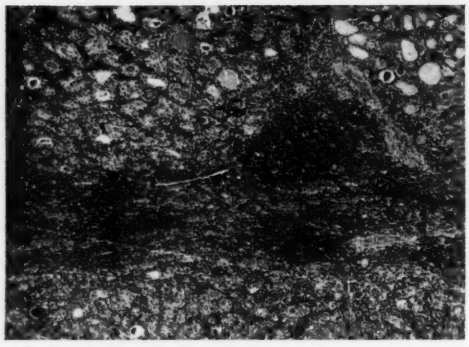

FIG. 376.—Microphotograph showing lymph follicles intermingled with thyroid tissue and diffuse infiltration of the stroma with lymphocytes and plasma cells. There are non-luminated epithelial islets as in Riedel's thyroiditis, but also certain areas where the acinar structure still appears fairly normal. The dense fibrous stroma of a typical Riedel's thyroiditis is not seen. (× 24.)

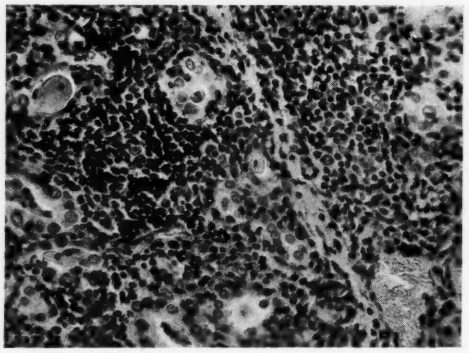

FIG. 377.—Microphotograph showing lymphoid tissue intermingled with thyroid tissue. There is diffuse infiltration of the stroma with lymphocytes and plasma cells. (× 150.)

I am indebted to Professor M. J. Stewart for his advice and pathological report, and to Mr. T. McM. Boyle for his report on the larynx.

CRYPTIC CANCER OF THE ANORECTAL REGION

By H. E. PEARSE, Taunton

In the *Proceedings of the Royal Society of Medicine*, October, 1946, Cuthbert Dukes mentioned 2 cases of colloid cancer of the anorectal region extending deeply along the track of a fistula-in-ano without forming a recognizable tumour in the rectum or anal canal. The following is a description of another such case.

CASE REPORT

H. W., a male aged 51, had suffered from a peri-anal boil twenty years before, which had left a posterior fistula-in-ano. One week before he was referred to me he was having a bath when he noticed a tiny projection at the external opening of the fistula.

When I examined him this projection looked like a tiny sebaceous horn $\frac{1}{8}$ in. long, forming a 'hood' to the opening of the fistula. I excised this with some underlying tissue for histological examination. Rectal examination gave normal findings.

The pathologist reported: "A small sessile tag of fibrous tissue, moderately infiltrated by chronic inflammatory cells and covered by thickened irregular squamous epithelium. The deeper tissues contain several infiltrating islets of columnar-cell adenocarcinoma, in places showing mucoid degeneration. This is clearly a secondary deposit from a colloid carcinoma of large bowel origin, and investigation of the rectum and sigmoid should identify the primary growth."

Further investigation of the rectum and sigmoid by palpation, proctoscope, sigmoidoscope, and barium enema failed to identify the 'primary growth'. However, fortified by Cuthbert Dukes's two cases, and after further consultation with the pathologist, I resected the rectum.

On naked-eye examination of the removed specimen no growth could be observed. On cutting a section carcinomatous growth was encountered. The specimen was handed to Dr. A. M. Thomas, of the E.M.S. pathological service, who reported that no carcinoma could be detected from the lumen of the rectum, but that the deeper tissues revealed a carcinoma of typical rectal colloid type, but associated with the fistula-in-ano (*Figs.* 378, 379).

This patient is now back at work again. He almost made his own diagnosis before any symptoms appeared, the only physical signs being an increase in the firmness and thickening of his fistula-in-ano when palpated, and its slight external projection. Biopsy is imperative in such cases.

I have pleasure in thanking Dr. Thomas for his microphotographs.

Fig. 378.—Carcinoma of rectum. Showing early carcinomatous acini and colloid formation. (× 15.)

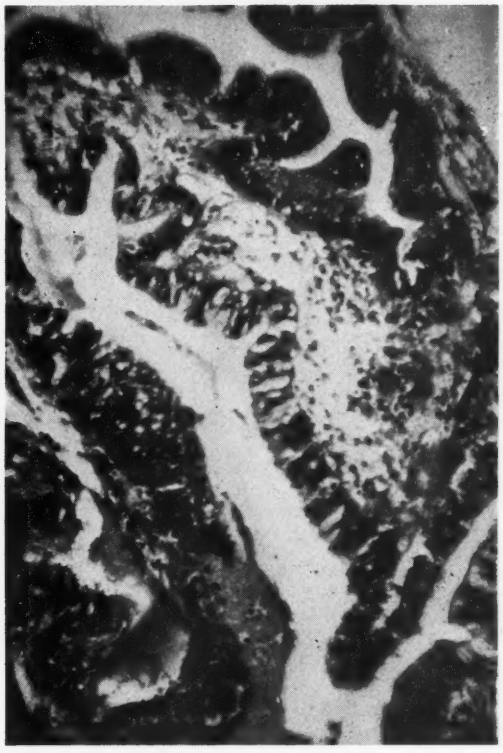

Fig. 379.—High-power view. Showing irregular acini lined by hyperchromatic cells in places several layers deep. Some are vacuolated and actively secreting mucus.

A CASE OF CYST OF THE SPLEEN

By E. V. BARLING and JOHN BORRIE

The reporting in increasing frequency of cysts of the spleen makes it essential to have this diagnosis in mind in all cases of upper abdominal tumour. The case reported below was presented to us as a left hypernephroma, but a careful history and physical examination, besides a combined examination of the alimentary and renal tracts by opaque media, enabled a correct pre-operative diagnosis to be made.

Fig. 380.—Retrograde pyelogram taken after a barium enema, showing displacement of splenic flexure and left kidney.

CASE REPORT

The patient, a young woman aged 17 years, was admitted to the Southend General Hospital on Oct. 8, 1946. Her presenting complaint was that she had had for the past three years a gradually increasing swelling in the upper left side of her abdomen. She associated the onset of the swelling with a fall downstairs. The swelling was accompanied by a dull ache and dragging feeling in the left hypochondrium. There was little else significant: she was gaining slightly in weight, suffered from flatulence, disliked greasy foods, and had some increased diurnal frequency of micturition. She had had similar dyspepsia at school, especially after fatty food. She thought that she was three months' pregnant. She had never had malaria, nor a previous operation. Both an aunt and an uncle were suffering from pulmonary tuberculosis.

On Examination.—She was a fit young woman, showing no abnormal findings in the mouth, lungs, or heart. The abdomen showed a large, smooth, painless lump which moved with respiration, extending from under the costal margin down as far as the umbilicus. No notch was palpable, and there was no tenderness or fullness in the costovertebral angles. The left loin was empty. The liver and right kidney were not palpable,

nor were there any palpable lymphatic glands in the groins, axillæ, or neck. The uterus showed enlargement consistent with uterogestation of three months.

The blood-count showed a microcytic anæmia, with Hb 66 per cent, but the white cells were normal in number and in their differential count. The blood-urea was 38 mg. per cent. Both Wassermann and Kahn tests were negative. Casoni and complement-fixation tests for hydatid were also negative.

In view of the history of initial trauma, and of the physical characteristics of the tumour, we made the diagnosis of old subcapsular hæmatoma of the spleen with subsequent cyst formation. This diagnosis caused considerable controversy with physicians who examined the case, who were convinced that the tumour was renal in origin. An intravenous pyelogram showed some doubtful compression of the upper calices of the left kidney, which appeared to be in a somewhat lower position than normal. It was then thought advisable to do a barium enema to see if there was any colonic abnormality. This showed downward displacement of the splenic flexure. Some 36 hours after the barium enema, a retrograde pyelogram was performed and a beautiful picture was obtained, showing that the renal calices were normal, but that both the left kidney and the splenic flexure were displaced downward (*Fig.* 380). This strongly supported a splenic origin for the tumour, further evidence to the same end being obtained by a barium meal, which showed that the stomach was displaced over to the right.

At Operation.—On Oct. 16 the abdomen was explored through a left Kocher incision, a large cyst of the spleen being found. There were no spleniculi and the liver was normal. On tapping, the cyst was found to contain altered blood and cholesterol crystals. Splenectomy was then performed (*Fig.* 381).

The abdomen was closed without drainage, and after the operation two pints of blood were given. Her convalescence was uneventful and she was discharged on Oct. 26. She has been seen since, is now very fit, and has recently given birth to her child.

Fig. 381.—The splenic cyst with splenic tissue peripherally.

Fig. 382.—Section of cyst wall showing lining epithelium.

Pathological Investigation.—Examination of the specimen showed it to consist of a unilocular cyst of the upper pole of the spleen compressing the rest of the splenic substance, which otherwise appeared quite normal. A section of the cyst showed it to contain serous fluid with cholesterol crystals, and a microscopical examination showed that there was an endothelial lining to the cyst wall (*Fig.* 382).

DISCUSSION

This case illustrates the fact that cysts of the spleen can be diagnosed pre-operatively, even though in the literature large numbers seem not to have been, probably because, as with most diseases, one must be alive to their existence before they can be diagnosed. It further illustrates the value of combined visualization of the renal and alimentary tracts as a means of establishing the presence of a splenic tumour.

Cysts of the spleen have been classified as follows :—

1. Parasitic : Hydatid.
2. Non-parasitic : *a.* True : Endothelial lining. *b.* False.

Fowler (1940) states that false cysts constitute about 80 per cent of the non-parasitic variety, and true cysts only 20 per cent. Included amongst true cysts are dermoid and epidermoid cysts, whose

origins are somewhat obscure, but which probably arise from cell-nests of multipotential cells. As Harmer and Chalmers (1946) point out, the presence of an endothelial lining does not indicate that it has been there *ab initio*, for such an endothelial lining may be acquired, particularly in cysts formed as a result of hæmorrhage into the splenic substance.

It would appear from the above classification that the case reported above is an example of a false cyst with a secondarily acquired endothelial lining.

SUMMARY

A case of false splenic cyst is described; and the value of simultaneous alimentary and renal tract examination with opaque media in establishing the pre-operative diagnosis is stressed.

We wish to express our thanks to Mr. Rodney Maingot for permission to submit this case for publication.

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REVIEWS AND NOTICES OF BOOKS

The Development of Inhalation Anæsthesia. With Special Reference to the Years 1846–1900. By BARBARA M. DUNCUM, D.Phil. (Oxon.), of the Nuffield Department of Anæsthetics, University of Oxford. 8¾ × 5⅝ in. Pp. 640 + xvi, with 161 illustrations. 1947. Published for The Welcome Historical Medical Museum by Geoffrey Cumberlege, Oxford University Press. 35s. net.

THIS volume gives a detailed survey of the history of inhalation anæsthesia from the discovery of nitrous oxide and oxygen, by Priestley, up to the end of the nineteenth century. The interesting and often dramatic series of events leading up to Morton's ultimate successful demonstration of ether at Boston, and the introduction of etherization into England, are given in engrossing detail. The author then continues with the discovery and adoption of chloroform in England and on the Continent, followed by the introduction of nitrous oxide, and terminating with a graphic account of anæsthesia at the end of the century.

The large number of illustrated reproductions and photographs of the numerous inhalers and other pieces of apparatus of the period are excellent and interesting; and the same may be said concerning the quotations and abstracts from the original letters and papers with which the context is interlaced.

The book as a whole is excellently produced and illustrated. By its careful account of the history of inhalation anæsthesia, it fills a long-standing gap in current anæsthetic literature.

Surgical Treatment of the Soft Tissues. Supervising Editor, FREDERIC W. BANCROFT, A.B., M.D., F.A.C.S., Associate Clinical Professor of Surgery, Columbia University; Associate Editor, GEORGE H. HUMPHREYS, jun., A.B., M.D., Sc.D., F.A.C.S., Valentine Mott Professor of Surgery, Columbia University. 10 × 7 in. Pp. 520 + xiv, with 244 illustrations. 1946. Philadelphia and London: J. B. Lippincott Co. 90s. net.

THIS large volume of over five hundred pages is devoted to the surgery of hernia, plastic surgery, burns, infections of the skin and subcutaneous tissues, neoplasms of the skin, tongue, and breast, and the surgery of the vascular and lymphatic systems.

The whole book is made up of contributions by some twenty-two authors, and of necessity the various chapters vary considerably in their style, diction, and usefulness.

The two outstanding chapters are those devoted to plastic surgery and burns. These two subjects have had a great stimulus owing to the second world war and much experience has been gained in them.

The chapters devoted to the treatment of the various forms of herniæ are quite commonplace and add nothing to our knowledge.

Infections of the hand are well described and illustrated.

Carcinoma of the breast is dealt with in a sound practical way, but the illustrations are for the most part poor and some are quite misleading.

The principles of arterial surgery are well set out, but most of the illustrations have been copied from articles which have appeared in various surgical journals and these have been poorly reproduced.

In a volume of this standing the illustrations are so important that the authors should have insisted on first-class material.

Surgical Pathology. By WILLIAM BOYD, M.D., M.R.C.P. (Edin.)., F.R.C.P. (Lond.), LL.D. (Sask.), M.D. (Oslo), F.R.S.C., Professor of Pathology, University of Toronto. Sixth edition. 9⅜ × 6¼ in. Pp. 858 + x, with 530 illustrations, 22 in colour. 1947. Philadelphia and London: W. B. Saunders Co. 50s. net.

THE new sixth edition of this well-known text-book of surgical pathology can be said to contain the best descriptive account of this important branch of pathology. The surgeon of to-day must know his pathology if he is to do his best for his patients. Osler wisely said "As is our pathology so is our practice", and this sagacious saying is as true to-day as it was when it was uttered.

This new edition has been pruned and revised, and a new chapter has been written on the pathology and pathological physiology of congenital heart disease, as this disease may now be said to come within the realm of the surgeon.

Other new material includes tumours of the larynx, Bittner's milk factor in relation to carcinoma of the breast, avitaminosis in cancer of the mouth, and fibrous dysplasia of bone.

The illustrations have always been a feature of this book, and several new ones have made their appearance in this edition, but it is a pity that the author has not deemed it wise to replace some of the older ones which

are quite dated by now. Some of the microphotographs are excellent and could not be bettered.

This book still holds pride of place in those which are devoted to surgical pathology.

Studies of the Renal Circulation. By JOSEP TRUETA, M.D., Hon. D.Sc. (Oxon.), ALFRED E. BARCLAY, O.B.E., D.M., F.R.C.P., F.F.R., F.A.C.R., PETER M. DANIEL, M.A., M.B., KENNETH J. FRANKLIN, D.M., F.R.C.P., and MARJORIE M. L. PRICHARD, M.A. From The Nuffield Institute for Medical Research, Oxford. 9⅝ × 7⅛ in. Pp. 187 + xix, with 83 illustrations. 1947. Oxford: Blackwell Scientific Publications Ltd. 25s. net.

THIS monograph is the outcome of team work from the Nuffield Institute for Medical Research at Oxford and is a great credit to that institution.

The co-operation of a clinician, a radiologist, a physiologist, and a pathologist in the investigation of a common problem is indeed an ideal which should lead the way to further discoveries.

The Regius Professor of Medicine, in writing a foreword to this work, considers that the authors have made a real contribution to our knowledge, and with this we heartily agree.

The study of vascular spasm is a subject that came to the fore in the early days of the war and the clinical entity of 'crush syndrome' was established, but Trueta and Barnes conceived the possibility of the renal vessels being involved in a proximally-spreading vasoconstriction in this condition.

The present volume contains the research work which has been carried out at Oxford since 1941.

The angiographic studies of the renal circulation in rabbits are fascinating and beautifully reproduced.

The intrarenal circulation has been demonstrated and the problems of cortical ischæmia, vascular pattern, and medullary circulation are described and illustrated in a masterly manner.

This book will stimulate further research in many directions and it will long remain the reference volume for all who are interested in the subject.

This volume is a real credit to the Oxford School; it is beautifully reproduced, excellently illustrated, and contains a comprehensive bibliography.

Surgery of the Hand. By R. M. HANDFIELD-JONES, *M.C.*, M.S., F.R.C.S., Surgeon to St. Mary's Hospital, etc. Second edition. 9⅝ × 6⅞ in. Pp. 164 + xii, with 104 illustrations. 1946. Edinburgh: E. & S. Livingstone Ltd. 20s. net.

"SOME books are to be tasted, others to be swallowed, and some few are to be chewed and digested . . . Reading maketh a full man . . . and if he read little he had need of much cunning to seem to know that he doth not."—Francis Bacon, *Essays*, "Of Sudies".

The first edition of this excellent book was published in 1940 and reviewed in this journal in January, 1941.

The reviewer then remarked, "The economic loss due to injuries and infections of the hand is so great that none can regard the present results of treatment with satisfaction . . . Mr. Handfield Jones is concerned to set right this deplorable state of affairs and it is not surprising to find in his book the vigorous dogmatic style of the Evangelist."

That reviewer would evidently have agreed with the present writer that the book is one which should be "chewed and digested", as no amount of "cunning" can change a bad result in an infection or injury of the hand into a good one. Moreover, this surgical Evangelist has a gospel to preach and not merely an epistle, to act as a reminder of a great surgical truth, viz., that what may be considered a minor procedure often involves, as in so many other walks of life, a major responsibility.

The present congestion of the Divorce Courts illustrates this and it is up to the surgical profession to see to it that the 'Compensation Courts' are not similarly overwhelmed.

In the Preface of this, the second edition, the author rightly states: "The men who have to treat infection, injuries, and diseases of the hand are general practitioners, industrial medical officers, and casualty house surgeons in hospital; it is for these of my colleagues that this book is primarily written", and later, "Penicillin will save lives and hasten recovery, but it is for us to preserve and restore function in one of the most beautifully designed instruments in the world".

The book should, then, be a vade-mecum for all casualty officers and not merely the newly qualified.

A prominent industrialist recently stated that the two injuries which accounted for most of the loss of skilled labour were the slight head injury, in which the man did not lose consciousness; and the slight hand injury which is treated by the unskilled and inexperienced, and at the end of a week is sent to hospital because "septic has set in".

Industrial and social medicine together with immediate and efficient first aid at the works is now playing a great part in improving the results of hand injuries. The former by creating the positive health of the employee and rectifying the cause of injury; the latter in applying the three great principles in the treatment of inflammation, viz., rest, non-interference with and improvement of blood-supply, the prevention of further infection. It has been wittily expressed that the difference between the living and the dead is that the former carries out its own repairs, in other words for an anatomical recovery the one essential is *Life* and all that it means. A good anatomical result usually implies a good functional result, though the latter can by judicious treatment often be attained at the expense of the former.

The frequency of injuries of the hand and their effect is quoted by the author (p. 9). In one year hand injuries amounted to 16·9 per cent of total unemployed but of these only 1·4 per cent needed evacuation to hospital and 0·4 per cent only because badly septic. Truly prevention is better than cure.

The author stresses the important part which the 'sulpha' drugs and penicillin play in the treatment, but insists that they do not relieve the surgeon of the major responsibility of preventing a contaminated wound from becoming an infected one.

Casualty surgeons will agree with the author that admission to hospital, so that rest can be attained, at any rate for a time, and a general anæsthetic for the surgical toilet given, are advisable but at the present time the general shortage of beds prevents this; nor is there the glamour or notoriety with hand surgery that accompanies the exploration of the recesses of the body. It is strange that this is so, as the result of a hand injury is patent to all, whereas the surgeon himself may have only a vague idea as to what has happened in the recess he has explored.

The book is dogmatic, but all good teaching of principles should be, and in laying down the general principles of treatment (pp. 9–14) the author states his 'Twelve Commandments' in italics. They might all be worded so that they begin with the words 'Thou shalt not' or 'Thou shalt' and so enable his audience to memorize them better. The same applies to the various 'cardinal rules' which he stresses on p. 75 and in other portions of the book where commandments are laid down.

They might even be collected at the end of the book in a revision summary, together with his many aphorisms such as "never make a median incision in dealing with an infected tendon sheath" and, in connexion also with

the same condition, " the temptation to incise both sides in order to introduce through-and-through rubber tissue drainage must be rigorously suppressed. There is no surer way to produce necrosis of tendons ", and again, " it is easier to preserve function than to restore it ". " If one hundredth part of the time spent in trying to mobilize stiff and crippled joints was devoted to preserving movement in the first few days, useless fingers would become rare things ".

The chapter on ' Infection in the Palm ' is excellent and the result of much experience in anatomy, diagnosis, and the surgery of access, and will repay every surgeon who studies and inwardly digests it.

Logically the second section on ' Injuries of the Hand ' should precede rather than succeed that on ' Infection of the Hand '. It is, however, more impressive to the young reader to realize his major responsibilities as early as possible before reading of what he might consider minor injuries.

Again, the author lays down ' ten commandments ' in dealing with the general principles of wound treatment (p. 112) and nine for amputations (p. 124).

If the first nine in the former are thoroughly carried out, then the tenth, " give antitetanic serum ", is unnecessary, but it will be a soporific for the surgeon.

The ninth might be changed from " suture wound if this can be done without tension " to " the only real dressing for a wound is skin " and the advantage of skin-graft, if necessary, to cover the wound could be stressed more than it is in the text, and also the type of graft which should be used.

It is wrong to leave all these cases to the plastic surgeon. Surgery cannot be divided into watertight compartments.

His advice about suture of tendons is sound, though it is very difficult to make any examinee agree to anything but secondary suture for all tendon injuries. It has become almost as much a dogma as the ' seventy-two hour ' appendicitis.

The third section of the book, on ' Other Surgical Lesions ', is not merely a make weight but does, so to speak, round off the whole subject.

The illustrations are excellent and the line drawings just what is wanted to make the text easily understood. The publishers are to be congratulated on the format of the whole book.

The author's style makes the reading so easy and interesting that every surgeon young or old will wish to possess his own copy. It should be in every Hospital Library, however small the casualty department, so that the House Surgeon on duty can refresh his memory on the many points presented by any hand injury that may come up. If this were so many hands mutilated by faulty treatment and ill-planned incisions and amputations would be avoided. Is it too much to hope that the Regional Boards will arrange that such libraries of reference books are instituted and kept up to date at every hospital?

Even so, they will be unable to insist that they are read. There will always be residents who will read little and need " much cunning to seem to know that they do not ".

Amputation Prosthesis. Anatomic and Physiologic Considerations, with Principles of Alignment and Fitting designed for the Surgeon and Limb Manufacturer. By ATHA THOMAS, M.D., F.A.C.S., Associate Professor of Surgery (Orthopedics), University of Colorado School of Medicine, and CHESTER C. HADDAR, President of the Association of Limb Manufacturers of America. 9 × 6 in. Pp. 305 + xii, with 207 illustrations. 1946. Philadelphia and London: J. B. Lippincott Co. 50s. net.

UNITY of purpose is not incompatible with diversity of opinion; there is no need to emphasize this, in these times. In no branch of surgery has there been a greater difference of opinion with regard to methods than in amputations. Some surgeons in the past, considering that amputation is a confession of failure, have almost forgotten that a patient had two legs but only one life; others, having little faith in prosthesis, have allowed a patient to keep a useless, even painful, limb and condemned him to crutches for the rest of his life. These ideas should be dissipated at once by reading this and other books which have been published since the 1914–18 war.

Amputation must be one of the oldest of operations. The only operation mentioned in the Bible, that of circumcision, is an example, but luckily no prosthesis is required. The authors define ' prosthesis ' as " the addition to the human body of some artificial part to replace one wanting " and then later qualify this with the trenchant sentence " It must also assume as nearly as possible the function of the lost member ".

Therein lies the difficulty, as anyone who wears an artificial denture will testify.

This book gives the American point of view. The authors are an orthopædic surgeon and the President of the Association of Limb Manufacturers of America, thereby stressing the point of view they emphasize throughout that to ensure the most successful outcome of an amputation there should be consultation and co-operation between the surgeon and artificial limb maker. If possible this should take place before the operation. In this way the most satisfactory site and method for the amputation can be determined, and the patient will know from the first that every care is being taken that the subsequent prosthesis will be as satisfactory as possible, and realize that this co-operation is also necessary for a successful outcome.

Considering the number of amputations of limbs which must have been done throughout the ages there has been very little thought given to prostheses until recently. Artificial limbs were obviously made and used. The authors state that they are mentioned in the Talmud, the plays of Aristophanes, and writings of Herodotus.

The oldest artificial leg in existence, they state, is in the possession of the Royal College of Surgeons of England. It dates from about 300 B.C. (Samite Wars) and was found in an ancient tomb in Capua (Fig. 1, p. 2).

Probably the most famous of all antique prostheses is the artificial hand worn by Goetz von Berlichingen (1480–1562). It is illustrated in Fig. 2, p. 3, and, as they rightly say, " is an amazing example of the craftmanship of the period (1509) ". It was exhibited in Berlin in 1916.

The first illustration of an amputation occurs in the book *Feldbuch der Wundartzney* by the Alsatian Surgeon, Hans von Gersdorff, published in Strasbourg in 1517. It shows one man with an amputation stump of the left forearm, wrapped in a pig's bladder, watching the surgeon amputate another man's right leg. It is also the earliest illustration of a tourniquet, but used incorrectly.

Amputation must have been very common in the middle ages on account of wars, leprosy, ergotism, and judicial punishment. It is commonplace that it was the problem which worried Ambrose Paré. That the problem of amputation and prosthesis is very real is shown by the number of amputees who have needed them both in the 1914–18 war and the last war.

In August, 1939, our own Ministry of Pensions published a book *Artificial Limbs and their Relation to Amputations* epitomizing the experience of the surgeons who had carried out this work since 1915, when " the great pioneer institution for limb fitting at Roehampton was inaugurated ". This was found to be necessary when it was realized " that both the selection and fitting of the limb, and the training of the man in its use, must be carried out under the personal supervision of a competent

surgeon ". The co-operation of the artificial limb maker was soon found to be necessary as well.

In June, 1916, the Army Council appointed an Advisory Committee composed mainly of surgeons and engineers " to consider the question of the best forms of artificial limb and the possibility of some measure of standardization in order to facilitate their supply and subsequent repair ".

It has only been possible both in this country and America to standardize materials and certain parts. It is quite impossible to adopt mass production for artificial limbs; each is an individual problem. The principles necessary for a good prosthesis are those laid down in this book and by our own Ministry of Pensions, viz.; simplicity of design, lightness of weight, and durability; and the materials used must lend themselves to the adjustments necessary for alinement and fitting.

These principles can only be carried out by the close co-operation of the surgeon, limb maker, and patient.

It is for the surgeon to make the amputation stump suitable to receive the prosthesis; the limb maker will then play his part; and, perhaps most important, is the patient's role, in which he should be encouraged by all to persevere in its use. In this way, only, can the prosthesis be made to assume the function of the lost member.

In 1917 the Ministry of Pensions was established and thereupon the provision of artificial limbs for disabled service cases devolved on the Minister. In 1920 there were 18 Regional Limb-fitting Centres.

The number of Centres was gradually reduced during the period between the wars, but sufficient work remained to enable the whole problem to be adequately studied by the authorities. The lessons thus learnt, by the painful experience of the amputees, and the patience and research of those making and fitting the prosthesis, resulted in the book already mentioned and published by the Ministry of Pensions in August, 1939. This was not because another war was anticipated but because the problem will be always present. Injury is not confined to warfare. Accidents and disease with their dire results always did and always will exist, perhaps even more so than in the past as the votaries of the god Speed increase in number. Hence the book published by our own Ministry of Pensions, and the one under review embodying the result of the experience of surgeons and limb makers in America, should always be at hand to be consulted by the surgeon who may have to do an amputation either as an emergency or as a considered and planned operation.

In 1941, War Memorandum No. 5 was published by the M.R.C. on *Emergency Amputations*. This was very necessary as the numbers were rapidly increasing. In this it was stated " A surgeon who amputates because of the severity of the local injury assumes a grave responsibility, particularly in the case of the upper extremity, and *a second opinion should always be sought before proceeding to this drastic step* ".

This of course may be unobtainable but it should always be remembered. The magnitude of the problem is indicated by the published figures. As a result of the 1914–18 war there were in this country about 41,000 cases of amputation; of these 11,600 were of the upper, and 29,400 lower, extremity. The latter included 17,000 above-knee amputations. By 1938 the Ministry of Pensions was responsible for approximately 34,700 cases.

By 1938 the total number of artificial limbs supplied by the Ministry was about 142,600 and the supply of new limbs continued at more than 4000 annually.

The number of amputations among the armed forces of U.S.A. during the 1914–18 war was relatively small—about 4000. It has been estimated that as the result of the whole war (1914–18) the total number of amputations amongst all nations participating was about 500,000.

During the American Civil War there were 30,000 amputations in the Union Army alone.

Up to July 1, 1945, over 15,000 amputation cases have been dealt with in the various amputation centres established by the U.S.A. Army and Navy authorities.

The figures for our own armed forces have not been published, but it is a conservative estimate to say that as the result of the last war (1939–45) there will be well over one million cases of amputation amongst all the nations taking part.

Quite apart from war injuries The American Federation of the Physically Handicapped estimate that there are approximately 75,000 new amputation cases annually in that country, of which 40,000 are major and require prosthesis.

The American National Safety Council reported that previous to the war (1939–45) accidents alone accounted for 32,500 amputations each year.

It is reliably estimated that there are 925,000 amputees living in U.S.A. at present, and the Artificial Limb Manufacturers of America report that they were annually supplying 70,000 persons with prostheses prior to the war.

The views in this book differ in some respects from those commonly held in this country. In both, the guillotine amputation under special circumstances is recognized as a life-saving measure.

There is a difference of opinion as to the value of the Stokes-Gritti disarticulation and the Syme amputation. In America the latter is favoured, and a suitable prosthesis can be fitted. Prof. Syme, in the 4th edition of his *Principles of Surgery* (1856), gave his reasons for recommending this operation. He did not stress amongst them the great advantage to the patient of being able to get about with no prosthesis except an 'elephant' boot, and not having always to have a crutch at hand both at his bedside and elsewhere.

What he didn't know, nor apparently do the authors, is the fact pointed out by the experts of the Ministry of Pensions that " The Syme stump gives good service so long as end-bearing can be tolerated ". They took 22 cases of the Syme's stump at random and investigated their ability to take end-bearing. Six cases took end-bearing for from 10 to 16 years and then needed re-amputation; the other 16 cases did not take end-bearing for so long a period. The authors give very full instructions for the preparation of the stump for the prosthesis. This of course must depend a good deal on sepsis, which is so common in accident cases. They consider that a suitable prosthesis should be fitted within four weeks and certainly not later than ten. Few surgeons in this country will agree wholly with this, but it is an obvious ideal.

It will be agreed by all the surgeons that with regard to upper extremity prostheses man amputees " desire them but few wear them " though the number which are helpful for following an employment is increasing.

The problem of the 'phantom' limb, both with regard to its cause and treatment, is fully discussed, with regard to the condition of the stump, the scar, the " endings " of the cut nerves, and the psychology of the patient. The value of sympathectomy, chordotomy, and resection of the post-central sensory cortex of the brain are discussed. All are unsatisfactory in most cases. They follow the advice of J. C. White (" Pain after Amputation and its Treatment ", *J. Amer. med. Ass.*, 1944, **124**, 1030) that it is always best to begin treatment " with a diagnostic blocking of the para-vertebral ganglia with procaine ".

The 'phantom' limb, however, remains the problem following amputations.

What does all this lead to? Surely the re-employment of the amputee. The last chapters of the book are of interest to everyone, lay and medical alike, on 'Reconditioning and Rehabilitation of the Amputee'. The

definition of reconditioning and rehabilitation should be remembered, viz., "a planned convalescence which has as its objective the return of the patient to his normal activities as soon as possible or (should a permanent handicap preclude this) enable him to make as happy and useful an adjustment as is possible, both mentally and physically".

It must therefore include physical, educational, occupational, and recreational phases, in order to achieve the best social and civil adjustment.

They continue, "There are four major objectives, the foundations of which will be laid in hospital. They are:—

"1. Social living, i.e., the routine pursuits of life.

"2. The ability to take care of himself, i.e., personal hygiene.

"3. The problem of transportation.

"4. The problem of employment with all its ramifications. Rehabilitation is for us the provision of those principles, techniques, and ideas which will help the amputee to solve these problems".

In the near future physical medicine or rehabilitation in its broadest sense will be under the aegis of the Regional Boards. They will do well to study and think of the above principles.

The important step in the physical restoration is the supplying of a satisfactory prosthesis. It conceals the defect and replaces the function which is lost.

In America there are many voluntary societies, as in this country, that interest themselves in this aspect of the amputee and deal with all classes from cripple children to war veterans.

What can be done is instanced by the fact that the Ford Motor Company has over 11, 000 handicapped persons on its pay roll. "Ten employees with both legs amputated . . . those with only one leg amputated are working at almost every kind of job". Henry Ford said "No man is really handicapped so long as he has the courage to go ahead and the willingness to do his part".

Every person has natural limitations, and the amputee should not be thought of as useless. "He is like the normal person in more respects than he is different."

Statistics taken in America amongst amputees show "less sickness, less absenteeism, and fewer accidents than amongst the non-handicapped".

The whole treatment can and will be improved if the aphorism of Sir Reginald Watson-Jones is remembered by the surgeon: "Amputation is the beginning and not the end of treatment".

A Descriptive Atlas of Radiographs. An Aid to Modern Clinical Methods. By A. P. BERTWISTLE, M.B., Ch.B., F.R.C.S. (Edin.). Sixth edition. $9\frac{3}{4} \times 7\frac{1}{8}$ in. Pp. 606 + xxix, with 948 illustrations. 1946. London: Henry Kimpton. 45s. net.

IT is a pity that this book, the sixth edition in twenty years, was not published in 1945, the jubilee of the discovery by Roentgen of X rays. It might then have been dedicated to his memory.

The dedication to the "Right Honourable Winston Churchill, O.M., under whose inspired leadership victory was won" will appeal to many as one who has conferred upon mankind as great a freedom from death and ruin as the discovery of Roentgen.

In 1945 was celebrated both the centenary of Roentgen's birth, and the jubilee of his epoch-making discovery.

The story of this discovery was told in the *British Medical Journal* (1945, **2**, 608), where it was pointed out that British scientists had played a great part in preparing the groundwork which made the discovery possible.

Since the discovery in 1895 X rays have played a more and more important part in medicine and industry. The use of these rays in medicine is not only for diagnosis but also treatment.

At first they were used for visual anatomy but gradually by the intensive research of those interested, visual physiology was achieved. In every anatomical and physiological department their use is demonstrated to students and as he passes to his clinical work he finds them used more and more. So much is this the case, that he is apt to neglect his clinical signs and symptoms, and, prompted by an anxious patient and friends, the doctor is inclined to send the patient for an X-ray examination without making a clinical investigation.

This aspect is really at the root of the argument whether an X-ray department should be an open one, whereby any doctor can have his patient X-rayed, or whether it should be closed and all cases referred to it, after being filtered through the various clinics. It depends of course entirely on the doctor. If the radiologist is provided with a full clinical history, with symptoms and signs, then he can accept the case as one needing his special investigation. If on the other hand a patient attends with a request "Barium meal, etc., please?" then it means that the radiologist must examine the patient clinically as well. The radiologist is far too hard worked for that, nor is he the person who should be asked to take such a responsibility. How often must a patient and doctor have been lulled into false security by the magical words 'X-ray negative'.

The same criticism applies in a lesser degree to establishing a radiological outfit in every separate clinic with no control by the radiologist.

The specialist, according to the well-known definition, knows more and more of less and less. By all means he must be interested in the X-ray findings, but he should be guided by criticism and discussion with the radiologist —many mistakes will be thereby avoided.

The general practitioners are agitating perhaps quite rightly for the proposed Health Centres to be equipped with an X-ray department and pathological laboratories, but these are apt to be expensive luxuries more than cheap necessities, if they are not under properly qualified and trained specialists. At present, as in all other branches of industry, there is not the man power and proper training takes years. Ultimately by a process of evolution the difficulties will be solved; it will take years, but better so than to try and produce specialists by revolutionary methods.

There is no longer the lack of teaching in radiology that the author bemoans, but the course is a long one and a basis of physics is necessary. Radiologists are being trained at many centres in London and the provinces, but more will have to be trained if the requirements under the National Health Act are to be met.

Radiology is no longer the Cinderella of British Medicine, relegated to basements and makeshift accommodation. It is rather a case of "The stone which the builder rejected . . ." and the modern hospital is now being built round the radiological department. The development of each new specialty makes additional call on the X-ray facilities. Each specialty provides perhaps one-tenth of the work and consumes one-quarter of a day for investigation of a particular case.

The book commences, as it should, with a chapter on "Milestones in Radio-diagnosis" which should be of interest to every medical man. The various systems are then taken *seriatim*, first the normal appearance being shown and then the abnormal contrasted with it. The reproduction of the radiographs leave little to be desired, and in times such as these must have taxed the ingenuity and patience of the publishers.

The radiology of bones and joints, normal, injured, and diseased, occupies a third of the book, but this does not mean that other systems are not fully dealt with.

The usefulness of radiology in obstetrics is only now being more fully appreciated. There is a section of the

book devoted to this aspect and in future editions it will certainly be expanded.

The present book is, as its name implies, a descriptive atlas. It is beautifully and thoroughly illustrated, and used in the proper manner should be kept at hand in every hospital library. There should be no hospital without an X-ray apparatus under the control of radiologists on a regional basis, and worked only by a competent radiographer technician.

The author himself points out in his sub-title that it is " an aid to modern clinical methods "—and he might add " not a substitute for them "—and in support of this quotes Sir James Paget's clinical essays (1875): " Use your eyes, your fingers, sometimes your nose, very seldom your ears ".

Surgery. A Textbook for Students. By CHARLES AUBREY PANNETT, B.Sc., M.D., F.R.C.S., Professor of Surgery, University of London; Director of the Surgical Unit, St. Mary's Hospital. Second edition. 9⅞ × 6⅜ in. Pp. 769 + xiv, with numerous illustrations. 1947. London: Hodder & Stroughton Ltd. 27s. 6d. net.

THE second edition of this text-book has been completely revised and brought up to date.

Professor Pannett has managed to condense into a book of less than eight hundred pages all that is necessary for a student to know about general surgery. Added to this, the illustrations are all from his pen and they are uniformly good and are of real value to the reader.

The book is full of useful facts and information which have been acquired from clinical observation over many years. The style is lucid and the reading is easy, and students will find in this text-book a faithful friend.

New Ways of treating Uræmia. The Artificial Kidney, Peritoneal Lavage, Intestinal Lavage. By W. J. KOLFF, M.D., Kampen, Holland. With the co-operation of J. VAN NOORDWIJK, P. S. M. KOP, N. K. M. DE LEEUW, and A. M. JOEKES. 9⅝ × 6⅜ in. Pp. 112, with 59 illustrations, several as plates. 1947. London: J. & A. Churchill Ltd. 10s. 6d. net.

THIS book gives an account of the pioneer work of the author and his collaborators on the construction and use of the artificial kidney. It includes chapters on peritoneal lavage, perfusion of an isolated intestinal loop, and high-caloric low-protein diets as methods of treatment of uræmia.

The work of Abel, Rowntree, and Turner in 1913 on " vivi-diffusion " was handicapped by the use of hirudine to prevent thrombosis, celloidine as the dialysing membrane, and the small capacity of the dialyser. The introduction of heparin and cellophane tubes has overcome the first two difficulties, and the author has attempted to overcome the last by building a large rotating cylinder carrying a cellophane tube up to 44 metres long and giving a filtering area of 24,000 sq. cm., which is greater than the corresponding area in the human kidney. The construction of the artificial kidney is shown by scale diagrams and photographs; the technical difficulties and the means of surmounting them are described in detail and accounts are given of all the cases treated, with graphs of the resulting fall in blood-urea and rise in urinary output. As a result of experience to date it is suggested that the artificial kidney should be used in acute uræmia when it threatens life, in post-operative uræmia and anuria, in mercurial nephrosis, and in chemotherapeutic anuria. In all these conditions it may be presumed that there is sufficient kidney tissue for function to be resumed naturally if the patient can be tided over the intoxication of the initial anuria. Up to 260 g. of urea has been removed in one dialysis as well as other retention products.

The work is an object lesson in the value of perseverance in overcoming difficulties. Of the first 15 patients treated only 1 survived; of the next 10 there are 7 survivors. Thus the faith displayed in the principle of the method has been vindicated, and it appears likely that when technical difficulties have been still further reduced it will become a valuable clinical procedure.

The book has been printed in Holland; the English is not without blemish, but we feel it is worthy of something better than a paper cover.

Harvey Cushing. A Biography. By JOHN F. FULTON. 9 × 6 in. Pp. 754 + xii, with 150 illustrations. 1947. Oxford: Blackwell Scientific Publications. (Springfield, Ill.: Charles C. Thomas.) 30s. net.

HARVEY CUSHING made sure that his biographer would have plenty of data to work on, and it must be generally agreed that John Fulton has performed the task of sorting this vast store of material, and selecting and arranging the substance of the biography supremely well. The only criticism one has heard has been in regard to its length—for it is a big book—yet it would be difficult, if not impossible, to eliminate any considerable part of it without at the same time substantially diminishing its value.

To trace the development of so remarkable a character is of absorbing interest, but the middle period of the life, while Cushing was making his great contributions to the physiology of the nervous system and to endocrinology as well as to surgery, is thrilling, and the story is so well told that it is hard to put the book down. Skilfully interwoven with the account of his neurosurgical activities and of the administrative problems of his hospital and university appointments there is the development of his magnificent library, which many a man would have been proud to leave behind as his sole claim to fame and honour. Yet in addition to all this was his own stupendous literary output, his gift of making appropriate speeches and addresses at the various functions he was called upon to attend, and his influence by precept and example upon the very large number of students, housemen, and young surgeons from all over the world who came to work under his direction.

All these facts of Cushing's life and character are faithfully portrayed, not only his glories and his triumphs, but also the defects in his temperament and personality, which some people found awkward, exasperating, or utterly impossible, while others, who realized that he was difficult because he was pursuing an almost unattainable ideal, found that these frailties made him more human and more lovable. For there is no doubt that he had a faculty for attracting young men, who worked themselves to the bone for him not merely because he was The Chief but because they worshipped him—and this is the cement-substance which binds together the Harvey Cushing Society.

John Fulton has been able to convey to his readers these and many more ideas in addition to the historic statement of Cushing's life's work, and in doing it he has followed scrupulously the method which Cushing himself practised when writing the biography of Sir William Osler —particularly in the care with which every page is ' headed ', and dated, and the almost complete exclusion of the biographer from the book.

BOOK NOTICES

[*The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest to our readers.*]

Cancer: Diagnosis, Treatment, and Prognosis. By LAUREN V. ACKERMAN, M.D., and JUAN A. DEL REGATO, M.D., Ellis Fischel State Cancer Hospital. 9¾ × 6⅞ in. Pp. 1115, with 745 illustrations and 9 coloured plates. 1947. London: Henry Kimpton. 100s. net.

The Parathyroid Glands and Skeleton in Renal Disease. By J. R. GILMOUR, M.R.C.P., Pathologist in E.M.S.; Junior Assistant Director, Bernhard Baron Institute of Pathology, London Hospital. 8½ × 5½ in. Pp. 157 + xiii, with 26 illustrations. 1947. London: Oxford University Press. 18s. net.

Pictorial Handbook of Fracture Treatment. By EDWARD L. COMPERE, M.D., F.A.C.S., and SAM W. BANKS, M.D., F.A.C.S., Northwestern University Medical School. Second edition, revised with the assistance of CLINTON L. COMPERE, M.D., F.A.C.S. Illustrations by HAROLD LAUFMAN, M.D., F.A.C.S. 8 × 5½ in. Pp. 390, with 191 illustrations. 1947. Chicago: The Year Book Publishers Inc. (London: H. K. Lewis & Co.). 30s. net.

Short Textbook of Surgery. By C. F. W. ILLINGWORTH, C.B.E., M.D., Ch.M., F.R.C.S. (Edin.), Regius Professor of Surgery, University of Glasgow. Fourth edition. 9¼ × 6 in. Pp. 680 + viii, with 227 illustrations. 1947. London: J. & A. Churchill Ltd. 30s. net.

Cancer of the Breast. By DUNCAN C. L. FITZWILLIAMS, C.M.G., M.D., Ch.M., F.R.C.S. (Edin. and Eng.), Surgeon to the Mount Vernon Hospital and the Radium Institute. 8½ × 5⅝ in. Pp. 199 + vii, with 20 plates. 1947. London: William Heinemann Medical Books Ltd. 25s. net.

Wayfarers in Medicine. Studies in the Progress and Triumphs of Medicine. By WILLIAM DOOLIN. 8½ × 5½ in. Pp. 284 + viii, with a number of plates. 1947. London: William Heinemann Medical Books Ltd. 21s. net.

Chronic Structural Low Backache due to Low-back Structural Derangement. By R. A. ROBERTS, B.Sc., M.B., Ch.B., D.M.R.E. 9¾ × 7⅜ in. Pp. 105 + viii, with 137 illustrations on 46 plates. 1947. London: H. K. Lewis & Co. Ltd. 45s. net.

Surgical Disorders of the Chest. Diagnosis and Treatment. By J. K. DONALDSON, B.S., M.D., F.A.C.S. (Lt.-Col., A.U.S.), Diplomat American Board of Surgery; Associate Professor of Surgery and in Charge of Thoracic Surgery, University of Arkansas School of Medicine; etc. Second edition, thoroughly revised. 9⅛ × 5¾ in. Pp. 485, with 148 illustrations. 1947. London: Henry Kimpton. 42s. net.

Sir Frederick Banting. By LLOYD STEVENSON, M.D. 9⅛ × 6⅛ in. Pp. 446 + xvi. Illustrated. 1947. London: William Heinemann Medical Books Ltd. 25s. net.

Essentials of General Anæsthesia. By R. R. MACINTOSH, M.A., M.D., F.R.C.S., D.A., Nuffield Professor of Anæsthetics, University of Oxford; and FREDA B. BANNISTER, M.A., M.D., D.A., Honorary Anæsthetist, Chester Royal Infirmary, late First Assistant, Nuffield Department of Anæsthetics, University of Oxford. Fourth edition. 8¾ × 5½ in. Pp. 358 + xi, with 247 illustrations. 1947. Oxford: Blackwell Scientific Publications Ltd. 30s. net.

Ulcers of the Stomach and Duodenum. Technique of Surgical Treatment. By EDMUNDO VASCONCELOS, M.D., F.A.C.S., Professor of Clinical Surgery, Faculty of Medicine, University of São Paulo, Brazil. 11⅜ × 8⅞ in. Pp. 125 + viii, with 154 illustrations. 1947. São Paulo: Editora Renascença S.A. Price not stated.

The Internal Fixation of Fractures. By CHARLES SCOTT VENABLE, M.D., F.A.C.S., and WALTER GOODLOE STUCK, M.D., M.S. (Orth. Surg.), F.A.C.S. With a Foreword by RALPH K. GHORMLEY. 10 × 6⅝ in. Pp. 237 + xii, with 84 illustrations. 1947. Oxford: Blackwell Scientific Publications. 30s. net.

The 1947 Year Book of Radiology. Edited by CHARLES A. WATERS, M.D., and IRA I. KAPLAN, M.D., F.A.C.R. Associate Editors: WHITMER B. FIROR, M.D., and SIDNEY RUBENFELD, M.D. 9 × 6 in. Pp. 416, with 287 illustrations. 1947. Chicago: The Year Book Publishers, Inc.

Neurological Complications after Spinal Anæsthesia. And Results from 2493 Follow-up Cases. By GUNNAR THORSÉN. Being Supp. 121, vol. XCV, *Acta chirurgica Scandinavica*. Translated by ULLA SCHÖTT. 9⅛ × 5¾ in. Pp. 272, with 11 figures and 5 plates. 1947. Stockholm: P. A. Norstedt & Söner. 15 kr.

Terapia endoarteriosa. By E. MALAN and G. ENRIA. With a Foreword by Professor A. M. DOGLIOTTI. 9⅝ × 6¾ in. Pp. 184 + vii, with 44 illustrations, a number as plates. 1947. Turin: Minerva Medica. L. 900.

The Essentials of Modern Surgery. Edited by R. M. HANDFIELD-JONES, M.C., M.S., F.R.C.S., and A. E. PORRITT, C.B.E., M.A., M.Ch., F.R.C.S. Compiled by 14 contributors. Third edition. 9⅝ × 6⅛ in. Pp. 1256 + xix, with 644 illustrations, many in colour. 1948. Edinburgh: E. & S. Livingstone Ltd. 50s. net.